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A DIGEST OF INFORMATION ON CHLORDANE

By

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The first announcement of the new insecticide now known as chlordane appeared in the December 1945 issue of the Journal of Economic Entomology. In an article by Kearns et al. (245) entitled "A New Chlorinated Hydrocarbon Insecticide" attention was called to a product having the empirical formula $C_{10}H_6Cl_8$ which had been found to be more toxic than DDT and to compare favorably in toxicity to the pure gamma isomer of benzene hexachloride to several species of insects. The compound, called 1068, was stated to be possibly a mixture of isomers.

CHEMICAL NAME

In the 1947 subject index of Chemical Abstracts chlordane is called 1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-4,7-methanoindene. In certain publications the name 1,2,4,5,6,7,8,8-octachloro-4,7-methano-3a,4,7,7a-tetrahydroindane has been used. [indan is 2,3-dihydroindene]. British patent No. 618,432 refers to the compound as octachlorodicyclopentadienedihydride.

COMMON NAME

The selection of the name "chlordane" for this chemical was announced on February 25, 1947, following conferences of representatives of the Bureau of Entomology and Plant Quarantine, the Production and Marketing Administration, the Food and Drug Administration, and the companies producing this insecticide. The name "technical chlordane" was proposed for the "commercially produced chemical containing 60 to 75 percent of chlordane, together with 25 to 40 percent of related compounds, occurring in the normal manufacturing processes, which are toxic to insects." The names "chlordane" and "technical chlordane" were recorded in the Patent Office as of February 27, 1947.

Murphy (341) pointed out that the terminal "ane" in chlordane is misdescriptive as it is properly reserved for saturated hydrocarbons and parent heterocyclic compounds. Chemical Abstracts and the other journals of the American Chemical Society refer to this compound as "chlordan", but the United States Department of Agriculture and industry call it "chlordane".

LABELING

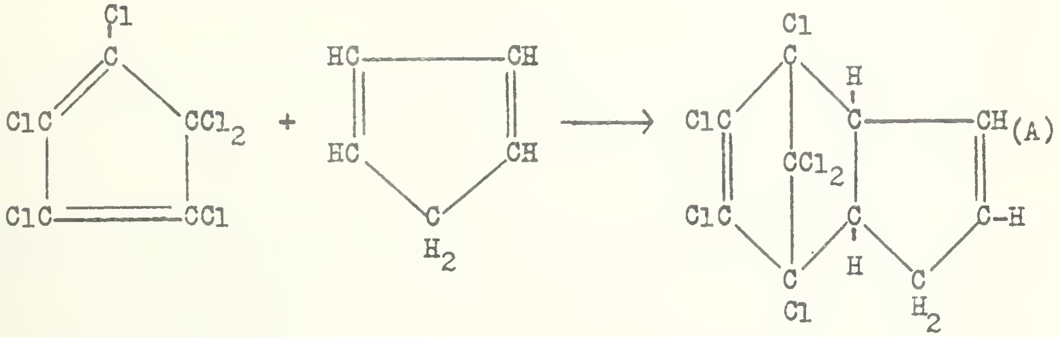
For the purpose of labeling insecticides under the new Federal Insecticide, Fungicide, and Rodenticide Act, the Production and Marketing Administration of the United States Department of Agriculture has approved the use of the shortened name - octachloro-4,7-methanotetrahydroindane.

It has further ruled that "Technical chlordane is the commercial product containing 60 percent to 75 percent of chlordane together with 25 percent to 40 percent of other related compounds, normally resulting from the manufacturing processes, and toxic to certain insects. All of its ingredients are, therefore, considered active under the Insecticide Act."

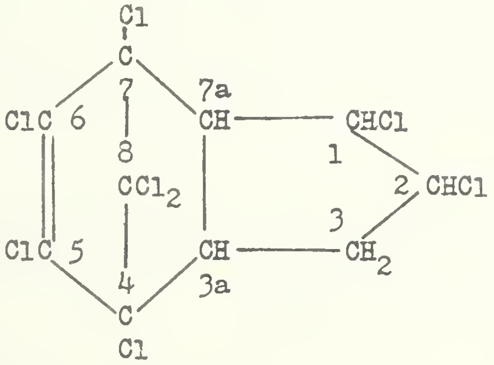
SYNTHESIS

The synthesis of chlordane is described in patents granted Hyman (232, 233). It is made by combining hexachlorocyclopentadiene and cyclopentadiene to form a Diels-Alder addition product of the formula $C_{10}H_6Cl_6$, to which chlorine is added to form $C_{10}H_6Cl_8$.

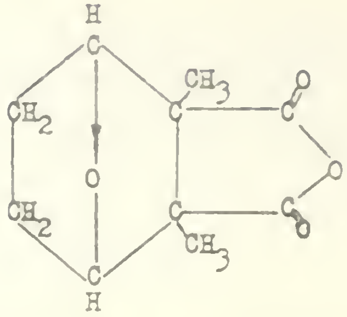
The reaction is as follows:



The adduct is dissolved in carbon tetrachloride and treated with chlorine gas with the resultant addition of two atoms of chlorine to the double bond (A) to form chlordane:



It is of interest to know that Riemschneider and Kuhnl (389) in Germany claim to have independently discovered the insecticidal properties of chlordane. They were led to prepare it from its structural analogy to cantharidin which they state is a contact insecticide. The structure of cantharidin is:



One of the insecticides developed by Riemschneider and Kuhnl, called M-410, is stated to have the same structural formula as that assigned to chlordane. No details are given regarding its synthesis or action on insects but it is claimed to be no more toxic than DDT to mice.

ANALYSIS

There are no specific chemical and physical methods for determining chlordane.

Ard (22) has described a qualitative test for chlordane in insecticide spray oils. The method consists in mixing 1 ml. of the sample in a test tube with 2 ml. of a Cellosolve-pyridine (40:10) solution and 1 ml. of an approximately 1 N solution of potassium hydroxide in 95 percent ethyl alcohol. When heated in a boiling water bath with occasional agitation for 5 minutes, the appearance of a red color indicates the presence of chlordane. A 1-ml. sample of 0.2% chlordane in a deodorized kerosene base gives a wine-red color of considerable strength, and 1 percent gives an intense dark red color. Very weak colors should be regarded as possibly due to other substances. A confirmatory test for chlordane is the appearance of an odor resembling that of a crude methylnaphthalene when the sample is dehalogenated with sodium in boiling isopropyl alcohol as is done in the determination of total chlorine. Toxaphene is the only other insecticide that yields a similar odor when subjected to this test.

Some chemists using Ard's method have pointed out that the red color developed is due to by-products in the technical grade of chlordane and that pure chlordane does not give this color. The method would appear to be applicable, however, if the amount of color-producing materials were a constant in the commercial product.

Alessandrini (10) modified Ard's method by substituting ethylene glycol for Cellosolve (the monoethyl ether of ethylene glycol). The coloration produced is less intense than in the original method. The presence of DDT does not interfere with the coloration.

Analyses of chlordane formulations by this method and by the determination of total and labile chlorine have been published by Alessandrini and Amormino (11).

Another colorimetric method for the identification and determination of chlordane specifies that 1 ml. of a 0.1 - 1.0 percent solution of chlordane in ethanol be mixed with 1 ml. N potassium hydroxide in ethanol and 1 ml. of a reagent prepared by dissolving 0.1 gram of p-aminophenol in 100 ml. of 80 percent ethanol. When heated to 100° C. for 5 to 10 minutes, the appearance of a blue color indicates the presence of 1 mg. or more of chlordane. None of the other common insecticides interferes.--Palumbo (355).

In the laboratories of the Division of Insecticide Investigations, Bureau of Entomology and Plant Quarantine, the total chlorine in chlordane is determined by decomposing the sample with sodium in refluxing anhydrous isopropyl alcohol and titrating the sodium chloride formed with N/10 silver nitrate solution, using an electrometric titrimeter. Chlordane is calculated by multiplying the total organic chlorine content by 1.44, a factor based on the fact that pure chlordane contains 69.22 percent of chlorine.

Romano (398) has pointed out that temperature, concentration of chlordane in solvent, and ratio of potassium hydroxide to solvent influence the dehydrohalogenation of chlordane and that a carefully standardized method is necessary in order to obtain reproducible results. Romano refluxes a solution of a 0.5 gram of chlordane in 20 ml. of petroleum ether with 20 ml. of N alcoholic potassium hydroxide at 80° C. for 30 minutes and determines the chloride by Volhard's method; 1 ml. 0.1 N silver nitrate = 47.6 mg. chlordane. This factor used by Romano is an arbitrary one. The loss of one chlorine atom from the molecule of chlordane, $C_{10}H_6Cl_8$, calls for the value 1 ml. 0.1 N silver nitrate = 40.8 mg. chlordane.

Davidow (98) in 1950 described a spectrophotometric method for the quantitative estimation of technical chlordane which is also applicable to the estimation of alpha-chlordane, beta-chlordane, heptachlor, and trichloro 237 (all present in technical chlordane) when only one is present. The procedure is to develop a colored reaction product by heating chlordane in n-hexane with diethanolamine-potassium hydroxide reagent in a boiling water bath for 30 minutes and note the absorbency at 521 millimicrons in a Beckman spectrophotometer.

Technical chlordane interferes in the method for the determination of heptachlor in which equal volumes of the suspect solution and a 0.5 molar solution of ethanolamine and of potassium hydroxide in butyl Cellosolve are mixed and heated in a boiling water bath for 15 minutes, the development of a pink to deep violet indicating the presence of heptachlor.--Velsicol Corp. (479).

Chlordane does not interfere in the colorimetric estimation of aldrin in which the aldrin is reacted with phenylazide to form a dihydrotriazole derivative which yields an intense red color when reacted with diazotized dinitroaniline in alcoholic hydrochloric acid.--Danish and Lidov (97).

PHYSICAL AND CHEMICAL PROPERTIES

Chlordane is a viscous, amber colored, nearly odorless liquid, boiling at 175° C. at 2 mm. pressure. It is insoluble in water and soluble in organic solvents such as aliphatic, aromatic, and chlorinated hydrocarbons, as well as in ketones, esters, and ethers. It is completely miscible in all proportions with deodorized kerosene, a solvent widely used for insecticidal products.—Kearns *et al*. (245); Sun (446); West (496). Its specific gravity range is 1.60-1.635 at 60° F./60° F., equivalent to a weight per gallon of approximately 13.3-13.6 pounds. The refractive index is 1.56-1.57 at 25° C.--Bussart and Schor (59).

It has been reported that Van Dyk 264 (N-octyl-bicyclo[2.2.1]-5-heptene-2,3-dicarboximide), a synergist for pyrethrins, will dissolve 50 percent of its weight of chlordane.—Anon. (3).

Chlordane dehydrohalogenates in the presence of alkaline reagents with concomitant loss of insecticidal activity. For this reason, it should not be formulated with alkaline solvents, carriers, or emulsifiers.

COMPATIBILITY

Frear (155) has published a table showing the compatibility of the common spray materials. Chlordane is represented as follows:

Chlordane mixed with:	Compatibility
Lead arsenate	Fully compatible
Calcium arsenate	Compatibility questionable
Paris green	Fully compatible
Cryolite	" "
Rotentone	" "
Pyrethrum	" "
Nicotine	Compatibility questionable
DDT	Fully compatible
BHC	" "
Toxaphene	" "
TEPP	" "
Parathion	" "
Summer oils	" "
Dormant oils	" "
Dinitro compounds	" "
Lime sulfur	Compatibility questionable
Wettable sulfur	Fully compatible
Lime	Compatibility questionable
Fixed coppers	Fully compatible
Bordeaux	Compatibility questionable
Dithiocarbamates	Fully compatible

Charts showing the compatibility of chlordane with other insecticides were published anonymously (1, 5) in the February 1948 and 1949 issues of the American Fruit Grower. Chlordane is represented as doubtful with basic lead arsenate, calcium arsenate, 40 percent nicotine, Bordeaux, glyoxalidines, lime sulfur, zinc sulfate plus lime, and lime; and compatible with all other insecticides and fungicides.

A mixture of chlordane 50-percent wettable powder with 4-8-8 fertilizer at the rate of 2 pounds to 1000 maintained insecticidal activity for at least 30 days.--Kelsheimer (252). Chlordane in certain fertilizer mixtures remained active for 192 days.--Compton (79).

Additional observations on the compatibility of chlordane with spray materials have been recorded by Marshall (316); and Griffiths and King (197).

The American Fruit Grower (Anon. 4, 6) has published charts showing the weather factors in spraying and dusting fruits with insecticides. Chlordane is listed as safe to apply to both pome and stone fruits under 5 weather conditions: temperature above 85°; temperature 85° to 65°; temperature 65° to 40°; light rain; high humidity with slow drying.

FREIGHT CLASSIFICATION

Beginning June 1, 1948 chlordane was shipped under a new item - "Polychlor Agricultural Insecticides and Fungicides" in the consolidated freight classification.

Polychlor is a name selected by the Classification Committee for a group of compounds, including DDT, benzene hexachloride, toxaphene, and chlordane which contain three or more chlorine atoms. This name is used only for shipping purposes, not for labeling. It was selected to avoid confusion among carriers as well as shippers over the long chemical names of this group of products, whose importance is increasing, and to avoid numerous requests for exceptions for individual products. All items in this group now will enjoy the same freight classification in their territory. Shippers should note that this new item does not cover the technical chemicals which should still be described as "chemicals, noibn"; likewise, it does not cover liquid preparations, or dry formulations in excess of 50 percent of the chlorinated chemical. Such formulations will continue to be described as "insecticides or fungicides, noibn".—Anon. (2).

PATENTS

Patents on chlordane have been granted Julius Hyman (231-233) as follows:

Belgium - Patent No. 464,617 granted April 16, 1946.
England - Patent No. 618,432 granted February 22, 1949.
Mexico - Patent No. 45,398 granted March 19, 1947.
United States - Patent No. 2,519,190 granted August 15, 1950.

The process disclosed in these patents is discussed under the heading "Synthesis" on page 5.

The adduct $C_{10}H_6Cl_6$ formed by combining hexachlorocyclopentadiene and cyclopentadiene in the first step of making chlordane has some insecticidal properties. This compound, called chlordene, has been patented for use as an insecticide by the Velsicol Corporation (475-477) and derivatives of it, for example, 1-hydroxy chlordene, 1,2-dihydroxy chlordene, and 1-acyloxy chlordene have been patented by Herzfeld et al. (213-215) assignors to the Velsicol Corporation.

GRADES AND SPECIFICATIONS

There is only one manufacturer of chlordane, the Velsicol Corporation, 330 East Grand Avenue, Chicago 11, Illinois, which calls its product "Velsicol 1068". Julius Hyman & Company, Denver, Colorado, formerly made chlordane which was sold under the trade name "Octa-Klor". On May 29, 1950 the United States Supreme Court refused to review the case of Julius Hyman, thus making effective a decree affirmed by the Supreme Court of Illinois which enjoins Julius Hyman & Company from making and selling chlordane.

The technical chlordane (AG grade) manufactured by the Velsicol Corporation (478) complies with the following specifications:

Property	Minimum	Maximum
Specific gravity at 60° F./60° F.	1.600	1.635
Weight per gallon (lbs.)	13.3	13.6
Color (Gardner-Hellige-1933)	—	14
Viscosity (centistokes at 130° F.)	45	70
Viscosity (SSU at 130° F.)	209	324
Total chlorine content (%)	64	66
Insolubles in deodorized kerosene at 20% V/V	—	None

The clarified grade is lighter in color than the AG grade, otherwise, its properties are the same.

FORMULATIONS OF CHLORDANE

The manufacturer of chlordane, the Velsicol Corporation, has issued several publications giving detailed directions for the preparation of chlordane formulations and these publications should be consulted by those intending to make a chlordane insecticide.

Chlordane is commonly employed in the form of solutions, emulsions, dusts, and wettable powders. Liquefied gas aerosols of chlordane have been tested and found to yield promising results.

Solutions of chlordane are easily prepared as it is readily soluble in the common organic solvents. It is miscible in all proportions with kerosene.

Emulsions containing chlordane can be formulated with or without a solvent (Mail, 311, 312). This is because chlordane is a liquid. The addition of small amounts of oil-soluble emulsifiers to oil solutions of chlordane makes emulsion concentrates which may be added to any desired amount of water. Also chlordane may be emulsified directly in water by the addition of a soluble emulsifier; however, in this case higher percentages of emulsifier must be used in order to maintain the same cream separation rate as that shown by aqueous emulsions made from oil-containing concentrates.

Twenty-two emulsifiers suitable for emulsifying a kerosene solution of chlordane in water are listed by Lidov et al. (298). An emulsifiable concentrate that produces a moderately stable emulsion is made by dissolving 1 pound of chlordane and 5 ounces of Atlox 1045 A (polyoxyethylene sorbitol oleate-laurate) in sufficient kerosene to make 1 quart. When added to water to make a 2-percent wt./wt. emulsion of chlordane, the resulting emulsion will show approximately two percent cream layer after standing 24 hours.

Chlordane dusts are prepared by first formulating a 50-percent by weight chlordane dust concentrate and then diluting this to the desired concentration. In preparing the dust concentrate, an absorbent type carrier such as diatomaceous earth should be used, and the impregnation process is carried out in a ribbon type blender. A weighed quantity of the absorbent carrier is placed in the blender, and an equal weight of the insect toxicant (heated to approximately 150° F.) is sprayed by means of air pressure through an orifice directly on the agitated carrier. The spraying orifice should be designed so that a finely atomized mist will be emitted which will cover a comparatively large surface of the carrier, and it should be placed approximately 12-14 inches above the surface of the carrier. If the orifice is at a greater distance from the carrier, the emitted droplets which cool on emission will become too viscous for efficient blending. In addition, if the effective spraying area is too narrow, the droplets will coalesce, and they will not blend satisfactorily with the carrier. The 50-percent dust concentrate is then run through a hammer or attrition mill for additional blending. A non-absorbent type of diluent or filler such as pyrophyllite is used to cut back the dust concentrate to the desired strength. The dusts finding the most universal application are those containing 5 percent and 10 percent by weight of chlordane. Chemicals having an alkaline reaction should not be used with chlordane because such materials can cause dehydrohalogenation of the insect toxicant.

Wettable powder - The manufacturing process for this product is the same as that used in preparing the 50-percent by weight dust concentrate.

Aerosols - In experimental studies a liquefied gas aerosol formula (G-556) containing 4 percent chlordane, 5 percent DDT, 5 percent piperonyl butoxide, 20 percent Freon-12, 66 percent methylene chloride, and enough carbon dioxide to develop 150 pounds per square inch pressure proved one of the best when sprayed on aluminum and masonite panels and tested for residual toxicity against confused flour beetles, American roach adults and nymphs, and grasshoppers.--Fulton et al. (160).

No aerosol formulas containing chlordane have been approved by the U. S. Department of Agriculture.

Proprietary insecticides that contain chlordane - The Arizona Agricultural Experiment Station (23) in 1948 listed 1004 products registered by 101 registrants in that state. Analyses are given of 6 chlordane formulations.

Frear et al. (156) in 1949 published a list of active ingredients in trade-marked pest control materials which includes about 40 products that contain chlordane.

EFFECT ON PLANTS

When added to the soil - When chlordane was added to Chester clay loam, Sassafras sandy loam, Evesboro fine sand and muck in the greenhouse, it depressed plant growth at relatively low levels without causing any obvious symptoms. Soil type and character, especially the quantity of organic material or colloidal clay present, are important factors in determining the toxicity of organic insecticides. Chlordane injures root systems more than DDT does and is more toxic to seedling plants than benzene hexachloride. Chlordane at the rate of 25 pounds per acre severely affected the germination of seeds.--Cullinan (93, 94).

When chlordane was added to the soil, it appeared to be toxic to all vegetable crops tested.--Foster (151).

Chlordane was mixed with Sassafras sandy loam by atomizing an acetone solution onto the soil particles while mixing at rates up to 400 pounds per acre (based upon 6 2/3-inch profile or 2,000,000 pounds of soil). The treated soil was distributed in 8-inch pots and each pot was planted to three 1-year-old Blakemore strawberry plants. Chlordane did not have any deleterious effect on the growth of the plants.--Goldsworthy (181).

Snap beans from plots treated with 297 pounds of chlordane 50-percent wettable powder per acre had a disagreeable odor when steamed in cotton-plugged flasks. About four months after treatment of the soil, cowpeas were planted after the beans and okra were removed. The vigor of the plants was much better than in untreated soil and these differences were not the result of root-knot which was quite severe on practically all the plots.--Ellis and Clayton (133).

At Corvallis, Oregon, in 1947, a 5-percent chlordane-talc dust at the rate of 27.5 pounds of toxicant per acre applied to the soil with a fertilizer spreader produced slight stunting and chlorosis of lima beans.--(333).

Chlordane was less toxic than benzene hexachloride (10-12 percent of the gamma isomer) to nitrifying bacteria and fungi when added to greenhouse soil at 100 and 500 pounds per acre.--Smith and Wenzel (426).

In tests at Bradenton, Fla., 50 pounds of chlordane per acre did not affect the germination of cabbage, lettuce, tomato, eggplant, and pepper. Chlordane 50-percent wettable powder mixed with 4-8-8 fertilizer at the rate of 2 to 1000 proved safe to use for a period of at least 30 days. Tomatoes grown in soil treated with fertilizer plus chlordane germinated normally. However, application of chlordane on tobacco seedbeds completely destroyed the germination.--Kelsheimer (252).

In tests at Belle Glade, Fla., chlordane either as a 5-percent dust or as a 40-percent emulsion was mixed with an 0-12-16 celery fertilizer and raked into the soil in amounts equivalent to from 2.4 to 15 pounds of toxicant per acre. Cabbage, pepper, tomato, and bean planted as seeds grew well in all plots; and none of the soil treatments gave any undesirable taste which could be detected in the raw cabbage.--Hayslip (211).

In Florida four pounds of chlordane per acre (in the form of a 50-percent wettable powder) increased the germination of sugarcane cuttings. Observations were made 19, 33, and 63 days after planting.--Bourne (42).

In Washington a reduction in stand of cucumber seedlings 14 days after planting was highly significant for treatment of soil with chlordane at the rate of 34.8 pounds per acre. This amount of chlordane also caused a lower stand of bush beans and turnips. No significant differences were found for any vegetables (bush bean, pole beans, beets, carrots, cauliflower, cucumbers, onions, squash, and swiss chard) tested in treatments of 5 pounds chlordane per acre. Chlordane seemed to reduce the quality of the fresh peas, pole beans, and bush beans, but was questionable for carrots and cucumbers.--Stitt and Evanson (441).

In Connecticut tests with potatoes grown in soil treated with chlordane at rates of 1, 2, 4, and 8 pounds per acre were inconclusive, but any resulting flavor from chlordane was much less objectionable than the flavor of benzene hexachloride.--Greenwood and Tice (196).

When applied directly to plants - In New Jersey established turf of various grasses and clover was sprayed with chlordane at the rate of 25 pounds per acre (50 pounds of 50 percent wettable powder per 1000 gallons of water), 2.5 times the rate used for control of Japanese beetle larvae. At intervals after treatment the grass was cut and weighed. The chlordane had no effect on the color, general appearance, or growth of the following grasses: redtop, Colonial bentgrass, Astoria bentgrass, Bermuda grass, orchard grass, meadow fescue, Chewings fescue, perennial ryegrass, Canada bluegrass, Kentucky bluegrass, and rough stalk bluegrass.

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In addition to these grasses, white clover grew normally. In field tests at five localities there was no indication that the application of chlordane at the rate of 10 pounds per acre had any adverse effect on the various grasses and clover.--Fleming (139).

In tests in Florida in 1947 and 1948, 5-percent chlordane dust and 50-percent chlordane wettable powder at 2 pounds per 100 gallons of water reduced the yields of cucurbits; in one case the dust reduced the yield of cucumbers below that of the check plot.--Kelsheimer (255).

Chlordane should not be used on cucurbits.--Schread (405).

In experiments at Geneva, New York, a dust containing 5-percent of chlordane produced characteristic symptoms of foliage injury on Blue Hubbard, Table Queen, and Butternut squash, representing the plant species *Cucurbita maxima*, *C. pepo*, and *C. moschata*. The injury was later outgrown and did not appear to affect the yield.--Carruth and Howe (66).

In Florida chlordane gave good control of insect pests of cucumber and squash without reducing yields in several tests, but in the fall of 1947, a wet season, it severely reduced the yield.--Kelsheimer (254).

In tests on curcubits in Oregon 5-percent chlordane dust, under moist conditions, caused slight burn on 2 varieties and chlorosis on 11 varieties.--Crowell and Morrison (90).

Peaches sprayed with nothing except chlordane developed foliage injury in June similar to what has been called *Bacterium pruni*.--Marshall (315).

Chlordane spray gave little if any protection against peach scab in West Virginia, but did not injure the fruit or foliage.--Gould and Taylor (182).

Chlordane 50-percent wettable powder at 2 pounds per 100 gallons of water was sprayed on peaches in North Carolina in 1948. Fruit from the chlordane plot was by far the best in two tests, but in another test it was even significantly worse than fruit which had received four applications of benzene hexachloride.--Smith *et al*. (420).

Chlordane emulsion, 0.5 pound toxicant per 100 gallons, caused moderate injury to *Kalanchoe globulifera coccinea* (referable botanically to *Kalanchoe blossfeldiana*).--Lumsden and Smith (303).

In North Dakota in 1948, a 5-percent chlordane dust at 35 pounds per acre gave the same yield (144 bushels per acre) of potatoes as did a 5-percent DDT dust. The untreated plot yielded 126 bushels per acre.--Munro *et al*. (340).

In North Dakota in 1947, a 5-percent chlordane dust gave a potato yield of 260 bushels per acre compared to 239.9 bushels per acre for the untreated plot. There were 5 applications of dust at the rate of 20 pounds per acre application.--Post et al. (370).

In tests on Red Warba potatoes in Winnipeg a spray of chlordane wettable powder yielded 317.2 bushels of potatoes per acre as compared to 83.7 in the check. A chlordane emulsion spray was somewhat less effective. None of the insecticides tested (toxaphene, chlordane, and DDT) impaired the flavor of potatoes tested as boiled potatoes and none of them injured the potato foliage.--Mitchener (330).

In New Jersey field tests potato plots sprayed with 50-percent chlordane at the rate of 2 pounds to 100 gallons of water, gave a lower yield than plots sprayed with the same dosage of 15-percent parathion or 25-percent benzene hexachloride.--Campbell (64).

Additional observations of the effect of chlordane on plants have been recorded as follows: No effect on the flavor of apples (Weinman 486); no phytotoxicity to the apple tree (Frezal 157); no injury to asters (Jefferson and Pence 239, 240); imparted a flavor to dried beans (Ristich and Schwardt 394); chlordane dust caused slight injury to the new growth of cantaloupes and cucumbers (Brooks and Anderson 48); chlordane emulsion applied to corn ears imparted an odor noticeable at harvest (Blanchard and Chamberlin 35); four dustings with 5-percent chlordane injured the corn (Tissot and Kuitert 456); potatoes grown in chlordane treated soil showed no off-flavor (Kulash 278); chlordane wettable powder spray severely burned the foliage of the Concord grape (Cox 84); and the foliage of prunes and also retarded growth of the tree and development of fruit (Cox 85); did not injure red clover (Marshall et al. 314); chlordane emulsion caused some injury to sweet potato foliage in the greenhouse (Harrison 206); at prescribed dosage levels chlordane did not injure grass but at extremely high levels (up to 150 pounds per acre) clover and bent grasses were retarded temporarily (Schread 409).

EFFECT ON ANIMALS

Earthworm

Chlordane 50-percent wettable powder at 1/4 pound per 100 gallons of water reduced the earthworm population of the fairway of a Florida golf course, but the control was not considered satisfactory.--Hayslip (211).

Snail

A 5-percent chlordane dust proved unsuccessful against Otala lactea, the milk snail, in the San Francisco Bay area in 1947.--Armitage (25).

Black widow spider

For black widow or other spider control, a light dusting of the area near where the webs are found is sufficient. The chlordane-impregnated dust settles on the web and the spider's first contact proves fatal.--Gilbert (174).

Fish

Chlordane is less toxic to fishes than is DDT but more toxic than benzene hexachloride. Applications of 1 pound to an acre to outdoor ponds killed 87 percent of the blue gill sunfish. With applications of 0.5 pound to an acre most of the bluegills as well as other species survived, and with those of 0.25 pound to an acre practically all fishes survived. A 12-percent chlordane solution (wt./vol.) in fuel oil was used in all applications.--Linduska and Surber (299).

Chlordane of 0.125 p.p.m. killed 100 percent and 0.05 p.p.m. killed 50 percent of goldfish in 4 days. The corresponding figures for DDT were 0.25 and 0.125 p.p.m.--Ginsburg (175).

Chlordane is less toxic to fishes than toxaphene. At Leetown, West Virginia, recent tests at 0.04 p.p.m. in still water failed to kill several species of warm water fishes, including bluegills, goldfish, and several minnows. Toxaphene killed all the fish tested at that strength. Chlordane at 1 pound per acre (in this case 0.16 p.p.m.) killed 87 percent of the bluegills tested. In streams and troughs in Alaska, chlordane proved to be more toxic to trout than DDT and similar to toxaphene in emulsion form in 15-minute treatments. As a suspension it was not toxic to trout in any strength tested below 15 p.p.m., and in fuel oil solutions up to 6 p.p.m. no damage was noted. It is concluded that chlordane appears to be damaging to some fish at 1 pound per acre.--Cope (80).

At a routine dosage of 0.1 pound per acre, chlordane is toxic to fish and will significantly reduce the population of ponds. At dosages of 0.05 pound per acre, DDT appears to be somewhat more toxic than chlordane. Chlordane appears to have no significant effect on the fish population at a dosage of 0.025 pound per acre. These tests were made on 32 species of fish in ponds.--Tarzwell (452).

Birds

Chlordane appeared to be 1/4 to 1/2 as toxic as toxaphene to game birds.--Post (369).

Mammals

(a) Rats and Mice - In tests made at the University of Illinois, chlordane and DDT appeared to be of the same order of toxicity to white rats, when administered as acute and repeated intragastric dosages and when inuncted percutaneously as an oil solution, emulsion concentrate and dilutions of the emulsion concentrate. Rats receiving either chlordane or DDT present a wide range of individual susceptibility, which makes it difficult to establish an absolute minimum or median lethal dose. Anorexia, loss of weight, hyperexcitability, and tremors were symptoms produced by both compounds. Tonic and clonic contractions were slightly more severe for those treated with chlordane. The time lapse between administration of an acute lethal dose and death is longer for chlordane than for DDT treated rats. There is some indication that chlordane may be slightly more toxic to female rats than to males. This was not observed to be true for DDT-treated rats. Chlordane appears to produce in rats less liver damage, but greater pulmonary damage than DDT.--Ingle (235).

Pharmacologists of the Food and Drug Administration found that the acute oral toxicity of chlordane to rats was LD-50 500 mg./kg., indicating that it is 1/2 as toxic as DDT. Chlordane is quite toxic when fed to rats at a concentration of 250 p.p.m. for 12 weeks. Rats have been seriously injured at this level and fail to survive on higher concentrations. Chlordane is a liver poison and also causes inanition in chronically poisoned animals.--Lehman (287, 290).

Chlordane is absorbed by the animal but its fate and whether or not the chemical is excreted in the urine is unknown.--Woodward *et al*. (509).

No harm resulted to rats, mice, or guinea pigs when they were subjected for 45 minutes on each of 38 days to air bearing aerosols containing chlordane with methylene dichloride or dimethyl phthalate as solvents, the average initial concentration of chlordane being approximately 1.9 mg. per liter. When aerosols with either kerosene, methylene dichloride, or dimethyl phthalate as a solvent were introduced into the chamber at intervals of 10 minutes over an hour in an initial concentration of 10 mg. of chlordane per liter, and this procedure was repeated three times on each of four successive days, many of the animals exhibited typical signs of poisoning by chlordane.--Heyroth and Witherup (217).

Stohlman *et al*. (442, 443) reported that the LD-50 of chlordane when fed to rats is 250 mg./kg. compared with 150 mg./kg. for DDT. Rabbits receiving chlordane excrete organically bound chlorine in the urine. The LD-50 of chlordane when administered intraveneously to rabbits is about 20 mg./kg. and this is increased to about 60 mg./kg. through the antidotal action of the barbiturates.

Frings and O'Tousa (158) reported that chlordane is very similar to DDT in its toxic action in mice. The first system affected in the nervous system, and nervous symptoms predominate in acute toxicity. In chronic intoxication, however, the liver seems to be most affected. The vapor of chlordane was toxic and wettable powder preparations proved surprisingly toxic.

(b) Dogs - Dogs starved for 24 hours were fed a 50-percent chlordane wettable powder in capsules with oil. It was concluded that chlordane, like benzene hexachloride, is a relatively safe insecticide to use upon dogs. Dogs vary in their susceptibility to chlordane. A dose of 200 mg./kg. produced convulsions in one dog, while a 700 mg./kg. dose had little effect on another dog.--Batte and Turk (29).

(c) Sheep, Cattle, Goats, Horses, and Pigs - Chlordane appeared from two to four times more toxic than DDT to sheep in acute toxicity. Sheep grazed on pastures sprayed with technical chlordane at rates up to 4 pounds per acre showed no apparent ill effects.—Hinman and Cowan (218).

At Bozeman, Montana, the maximum safe, single dose of chlordane for sheep appeared to be considerably less than 0.5 g. per kg., and for cattle no toxic effect was produced by 0.05 g. per kg. The effects of daily dosages of chlordane administered in capsules for 60 days were: a capsule of 4.5 grams of a mixture of chlordane and xylene (3.5 grams chlordane) was extremely toxic and half this dosage proved about as toxic. A dose of 1 gram of chlordane-xylene mixture (0.77 grams chlordane) was continued to the end of the experiment producing only mild symptoms. Sheep dosed with capsules containing 2 grams of xylene alone gave no reaction, indicating that the chlordane was the toxic agent. Six sheep grazed for 21 days immediately following spraying of 1 pound and 4 pounds chlordane per acre showed no indication of toxic effect.—Welch (491).

Wettable powders containing less than 1 percent of chlordane had no ill effects on cattle, sheep, goats, hogs, and horses.—Laake (280).

In toxicological experiments with chlordane at Kerrville, Texas, dipping goats or sheep with chlordane wettable powder or emulsion did not cause symptoms of poisoning until after six to eight dippings in 1.5-percent chlordane at 4-day intervals. Marked symptoms of poisoning developed in all animals after the last dipping and fatal results ensued. Cattle likewise failed to show toxic symptoms until after four sprayings at intervals of 2 weeks with 2 percent chlordane wettable powder suspension when severe symptoms occurred followed by death. The dip and spray liquids were six and eight times the recommended strength, respectively, and the frequency of application was much greater than in actual field practices. Acute poisoning is characterized by sudden onset, with bleating, groaning, grinding the teeth, blindness, violent struggling, and bluish discoloring of the skin before death. In subacute and chronic poisoning the onset is gradual with partial to complete blindness and locomotor ataxia, circling, staggering, avoiding imaginery objects, and periodic convulsions. Post mortem findings consist of petechiae and larger hemorrhages under the serosa of the large and small intestines and the epicardium, fatty changes of the liver, and congestion of the brain.—Radeleff (381), Bushland et al. (58), U. S. Bur. Animal Ind. (464), U. S. Bur. Ent. and Plant Quar. (468).

(d) Man - Undiluted "Velsicol 1068" caused mild irritation of human skin, under the conditions represented by conventional 48-hour patch tests upon 58 subjects. When diluted in mineral oil and employed in 48-hour patch tests in a 1 percent (by volume) solution, "Velsicol 1068" caused no irritant effect.—Goldman (180).

Chlordane applied to the skin causes moderate irritation; the quantity considered dangerous upon skin application in solution is for single exposure 1880 mg./kg. and for multiple exposure 40 mg./kg. The The quantities dangerous to man are: for single exposure 113 grams and for multiple exposure 2.4 grams per day. The hazards of aerosol formulations of chlordane can only be surmised.—Lehman (288).

On the West coast only one case of dermatitis among pest control operators using chlordane has been reported and the patient in the patch test showed sensitivity to both petroleum solvents and undiluted chlordane. It is concluded that chlordane is probably no more hazardous than many other standard products used in the industry.—Jacobs (238).

The council on Foods and Nutrition of the American Medical Association (17) in a recent statement called attention to the danger to public health created by the wide use of synthetic insecticides and urged that controls be placed on the sale of products of unknown or incompletely known toxicity. The effects of inhalation and skin absorption of these synthetics must be determined as well as their chronic toxicity to man.

Toxicological information on chlordane has been summarized as follows: Local effects: - Chlordane is moderately irritating to the skin. This property is lost on dilution, as in insecticide formulations, and the warning sign of danger is lost. The insecticide is absorbed through the skin, and it has been estimated that daily exposure to about 2.4 grams in solution may be dangerous to man. Symptoms: - The early signs are those of irritability of the central nervous system. This leads eventually into convulsions, which are followed by a period of depression with or without a final convulsion seizure. Fatal dose: - From the acute standpoint chlordane appears to be only about one-half as poisonous as DDT, but the side effects are such that in the final analysis the toxicity is about 5 times that of DDT. Therefore, the fatal dose lies somewhere between 6 and 60 grams. Fatal period: - The onset of symptoms is within 45 minutes after ingestion. Deaths occur occasionally within 24 hours, are frequent between the 48th and 96th hour, and if survival extends to the 6th day, recovery is the rule. Pathology: - Inanition is a predominant observation in chronic poisoning, indicating a considerable disturbance in normal physiology. Of the vital organs, the liver bears the brunt of the poisoning, and the usual degenerative changes produced by chlorinated hydrocarbons are a constant finding. Treatment: - The usual measures should be adopted for removing the poison from the stomach and intestinal tract. Any additional treatment must be symptomatic as no specific antidotes are known.—Lehman (290).

A comparison of the acute oral doses shows that the compounds arrange themselves in the following order from the most toxic to the least toxic: tetraethyl pyrophosphate, parathion, hexaethyl tetraphosphate, toxaphene, gamma isomer of benzene hexachloride, DDT, chlordane, TDE, methoxychlor. Chronic feeding data indicate that parathion is the most toxic, the sequence being parathion, beta isomer of benzene hexachloride, chlordane, DDT, gamma isomer of benzene hexachloride, alpha isomer of benzene hexachloride, toxaphene, TDE, delta isomer of benzene hexachloride, methoxychlor.—Lehman (289).

Additional reports on the toxicology of chlordane have been published by Lehman (291-295). Chlordane presents the greatest all-around hazards of the commonly used chlorinated insecticides and therefore has no place as a contaminant of foods and its household use should be strictly limited. Long-term feeding studies indicate that at every level of feeding chlordane is significantly more poisonous than comparable levels of DDT. From the over-all aspects chlordane is at least 4 times as toxic as DDT.

SPRAY RESIDUES OF CHLORDANE

In Colorado, Gates (172) in 1948, found chlordane residues on alfalfa after the application of one pound of the toxicant as an emulsion per acre as follows: cut 8 hours after treatment 17.9 p.p.m., 5 days 13 p.p.m., 10 days 4.5 p.p.m., and 15 days after treatment 3.4 p.p.m. A test on houseflies with an extract of the hay cut the first day indicated a chlordane residue one-half that calculated from the total chlorine content.

When chlordane was applied to apple and peach foliage at the rate of 1 pound (an emulsion concentrate) per 100 gallons of water, the initial deposit was 90.2 p.p.m. on apple foliage and 139.5 p.p.m. on peach foliage. After 21 days these values fell to 8.3 p.p.m. and none, respectively. Residue determination on alfalfa, sweet clover, red clover, and soy beans indicated that lindane and parathion residues are the least persistent followed by aldrin, chlordane, dieldrin, toxaphene, and DDT in that order. The waxy nature of chlordane residue makes it resistant to removal by rain. Chlordane residues were determined by the total chlorine method using the factor Cl x 1.57 = chlordane.--Decker et al. (101).

Chlordane in milk - A spray containing 0.5 percent of chlordane as a wettable powder was sprayed on milk cows four times between May 15 and August 29. Milk from these cows sampled from May 22 to October 27 showed a maximum organic chlorine content of 0.8 p.p.m. and an average of 0.2 p.p.m. It was concluded that these amounts are so small that they are not regarded as definitely indicating the presence of chlordane in the milk.--Carter et al. (67).

The danger of chlordane in milk to the public health was recognized by the United States Production and Marketing Administration (474) which on May 12, 1949 sent a notice to manufacturers, registrants, and distributors of insecticides containing chlordane warning against the use of chlordane on dairy animals, or on forage or other feeds for dairy animals or animals being finished for slaughter, or for use as insecticides in dairy barns.

The American Medical Association (16, 17) has expressed concern over the contamination of the American diet with new materials of unknown toxicity such as chlordane and has urged that voluntary control by the producers and distributors of the pesticides be instituted immediately.

INSECTICIDAL USES OF CHLORDANE

The literature records the results of tests of insecticides containing chlordane on the following kinds of insects and other arthropods:

Class and Order	Families	Genera	Species
Orthoptera	3	14	21
Isoptera	2	2	2
Thysanoptera	1	5	5
Anoplura	2	3	5
Mallophaga	3	6	8
Homoptera	8	19	22
Hemiptera	5	16	19
Coleoptera	12	42	45
Lepidoptera	11	31	37
Hymenoptera	4	12	17
Diptera	12	20	39
Siphonaptera	1	1	-
Acarina	7	12	16
Total	71	183	236

DIPLOPODA

Millipedes

Chlordane, 1 pound per acre, had little effect on millipedes in grain fields.--Severin (414).

SCORPIONIDA

Scorpions

In Arizona a 2-percent solution of chlordane in oil killed scorpions in from 12 hours to 3 days. Chlordane killed more quickly than DDT, but did not last as long. The best all around mixture for scorpion eradication at present seems to be 2 percent chlordane, 10 percent DDT, and 0.2 percent pyrethrins in an oil spray-base.--Stahnke (437).

ORTHOPTERA

Acrididae

Grasshoppers are readily killed by the application of chlordane and it is used on a large scale for their control. There appears to be little difference among species in their susceptibility to chlordane and because of this the results of tests with one species are about the same as those with another. Severin (415) reported chlordane to be effective against 35 species of grasshoppers.

Relative toxicities of chlordane and other insecticides to grasshoppers - In the laboratory Kearns et al. (245) made stomach poison tests with chlordane, DDT, and gamma-BHC on the adult grasshopper Melanoplus differentialis (Thos.). Emulsions of xylene solutions of the active compounds were fed to the grasshoppers in measured drops. Twenty-four hour mortality records indicated the median lethal dosage for gamma-BHC to lie between 5 and 10 micrograms, for chlordane between 12.5 and 25 micrograms, and for DDT to be greater than 50 micrograms per gram of body weight.

Rhoades and Brett (388) made laboratory tests on three economic species of grasshoppers, Melanoplus bivittatus (Say), M. differentialis (Thos.), and M. mexicanus mexicanus (Sauss.), to determine their susceptibility to certain synthetic insecticide dusts under different constant temperatures. A 10-percent chlordane dust was slower acting than 2-percent parathion and 5-percent gamma-BHC dusts, requiring from 48 to 72 hours to reach peak mortality. High temperature increased its effectiveness to a lesser extent. Chlordane was less effective than the other materials except DDT in its action as a contact toxin. There was little difference in the relative susceptibility of the three kinds of grasshoppers to the different insecticides.

In laboratory tests against Zonocerus elegans (Thunb.) by Petty (363) in South Africa a 2-percent parathion dust proved superior to a 5-percent chlordane dust. In general, 10-percent BHC causes a quicker rate of mortality than 5-percent chlordane, although the final mortality obtained with the two insecticides is similar. A 5-percent BHC concentration appears to be too weak for effective control and 10-percent DDT is relatively ineffective. There is some indication that young hoppers are more susceptible to the poisons than the older ones or adult insects. The results suggest that a 5-percent chlordane dust should be effective at the rate of 20 pounds per acre.

LePage et al. (297) in Brazil, using Schistocerca cancellata (Serv.) as the test insect, found that a 5-percent chlordane dust was more toxic than dusts containing 10 percent of dinitro compounds or 20 percent of toxaphene but was less toxic than dusts containing 0.25 percent parathion, or 1 percent of gamma-BHC.

Kearns et al. (246) made laboratory tests on the grasshopper (M. differentialis), housefly, American and German roaches, milkweed bug, codling moth larvae, black carpet beetle, webbing clothes moth, plum curculio, chinch bug, and two-spotted mite with several insecticides. The relative toxicity of these materials was: dieldrin > aldrin = heptachlor = gamma benzene hexachloride > chlordane > toxaphene > DDT. The residual effectiveness of the materials was: dieldrin > DDT > aldrin > heptachlor = chlordane > gamma benzene hexachloride.

Weinman and Decker (489) in Illinois conducted one-quarter acre plot tests against 3 species of grasshoppers, *Melanoplus differentialis*, *M. femur rubrum* (Deg.), and *M. mexicanus*. One pound of chlordane was about as effective as 2 pounds of toxaphene and was more rapid in action. Toxaphene showed a somewhat longer residual action than chlordane at relatively high dosages. The LD-50 values for chlordane against *M. differentialis* adults when tested for contact effect were 16.3 in 1947 and 9.8 in 1948; when tested for stomach-poison effect, the values were 21.8 and 12. In these tests parathion and the gamma isomer of BHC proved more toxic and toxaphene and DDT less toxic than chlordane. There was some evidence of slight synergism in mixtures of DDT and chlordane. The greater the ratio of DDT to chlordane, the greater the synergism.

Gaines and Dean (169) in Texas determined the relative toxicity of certain insecticides to first to third instar nymphs (*M. differentialis*) when applied as contact sprays and dusts to be as follows:

	MLD, pounds active ingredients per acre	
Treatment	Spray emulsions	Dust
Toxaphene	1.17	1.73
Chlordane	.49	1.49
Parathion	.05	.17
Benzene hexachloride	.04	.17
Lindane	.08	

The materials applied as sprays made from wettable powders were as effective as when applied as spray emulsions made from miscible oil concentrates. However, the dosages required to kill adults were considerably higher than those required to kill the first and second instar nymphs. In the field tests chlordane and toxaphene were approximately equal in toxicity to young grasshoppers when applied as spray emulsions. Dieldrin was more toxic to grasshopper nymphs than benzene hexachloride, chlordane, aldrin, or toxaphene.

Chlordane was first tested against grasshoppers in the field in the summer of 1946. A dust containing 5 percent of chlordane applied at the rate of 25 pounds per acre killed more than 90 percent of the grasshoppers in a Missouri apple orchard and prevented re-infestation for 30 days.--Wingo *et al.* (501).

Numerous field tests of chlordane against grasshoppers have been conducted in Argentina (Parker, 356), Canada (Putnam, 379), South Africa, Australia, Salvador (Zuniga *et al.*, 515), and many of the states. The following report by Parker (357), of the U. S. Bureau of Entomology and Plant Quarantine, of field tests made in Arizona, California, and Montana in 1947 presents results typical of those found by other workers.

When applied in sprays or dusts, chlordane and toxaphene caused high mortalities within 24 hours and continued to kill over a period of 1 to 4 weeks. Each of these materials was as effective in oil solutions as in emulsion and when applied from the ground as from airplanes. Chlordane at 1 pound per acre in such formulations reduced grasshopper populations

90 to 99 percent in 3 days or less. A suspension at this dosage gave 90 percent kill, and dusts averaged 99 percent kill when applied by airplane and 64 percent by ground equipment. In field tests with baits 0.5 pound of chlordane, 1 pound of toxaphene, 1 pound of parathion, or 0.1 pound of the gamma isomer of BHC per 100 pounds of carrier gave 10 to 15 percent higher kills than 6 pounds of sodium fluosilicate.

Chlordane, applied as an emulsion at the rate of 1 and 1.5 pounds per acre to roadside and field vegetation in Kansas, caused an average reduction of 84 percent in grasshopper population at the end of 72 hours and 100 percent at the end of 7 days.--Butcher *et al.* (60).

In tests made at Fort Collins, Colorado, in 1946, chlordane gave nearly 100 percent control in 8 days or less when applied as a 5-percent dust at 20 pounds per acre, or as a spray, 2 pounds per 100 gallons, at 50 gallons per acre. For use as a spray 1 pound of chlordane was dissolved in 1 quart of xylene with 50 cc. of Triton X-100 and this then added to 50 gallons of water.--Weihing and Hoerner (485).

Aerosol formulation G-556 containing 4 percent chlordane, 5 percent DDT, 20 percent Freon-12, 5 percent piperonyl butoxide, and 66 percent methylene chloride killed 50 percent of grasshoppers, confused flour beetles, and American cockroaches when they were exposed to 4-day old residues of it applied at 75 mg./sq. ft. of DDT. The kill was increased to about 80 percent when the residue was tripled.--McBride *et al.* (305).

Reports of tests of chlordane against the following species of grasshoppers have been published:

Aeolopus turnbulli bruneri Caud., the thistle grasshopper
  Butcher *et al.* (60).
Camnula pellucida (Scudd.), the clear-winged grasshopper
  Armitage (25), Hinman and Cowan (218), Parker (357), Wilson (497).
Chortoicetes terminifera (Wlk.)
  Allman and Wright (15).
Hesperotettix speciosus (Scudd.)
  Butcher *et al.* (60).
Brachystola magna (Gir.), the lubber grasshopper
  Severin (415).
Melanoplus bivittatus (Say), the two-striped grasshopper
  Brett and Rhoades (45, 47), Butcher et al. (60), List and Hoerner (301), Munro et al. (337), Rhoades and Brett (388), Severin (413).
M. differentialis (Thos.), the differential grasshopper
  Armitage (25), Brett and Rhoades (45), Butcher et al. (60), Gaines (163), Gaines and Dean (166), Graham (190), Hinman and Cowan (218), Kearns *et al.* (246), List and Hoerner (301), Parker (357), Rhoades and Brett (388), Severin (413), Shotwell (419), Weinman and Decker (488, 489), Weinman *et al.* (490), Wilson (497).
M. femur-rubrum (Deg.), the red-legged grasshopper
  Armitage (25), Butcher *et al.* (60), Graham (190), Hinman and Cowan (218), Hutson (230), List and Hoerner (301), Parker (357), Severin (413), Sun *et al.* (450), Weinman and Decker (488, 489), Weinman *et al.* (490).

M. marginatus Scudd.
Armitage (25), Parker (357), Wilson (497).
M. mexicanus devastator Scudd., the devastating grasshopper
Hinman and Cowan (218).
M. mexicanus mexicanus (Sauss.), the lesser migratory grasshopper
Armitage (25), Brett and Rhoades (45), Butcher et al. (60), Brown (49), Brown and Hurtig (51), Hinman and Cowan (218), Munro et al. (337), Parker (357), Rhoades and Brett (388), Severin (413).
Schistocerca americana (Drury), the American grasshopper
Griffiths and King (197), Griffiths et al. (198), King and Griffiths (262), Thompson and Griffiths (454).
Zonocerus elegans (Thunb.)
Petty (363).

Chlordane has been recommended for the control of grasshoppers by the state entomologists of California (25), Georgia (382), Illinois (234), Indiana (375-378), Missouri (328, 329), Oklahoma (279), South Dakota (416), and Wisconsin (503, 505). Young grasshoppers may be controlled by 1/2 pound of chlordane per acre but the full grown ones require 1 pound per acre. Emulsions have given the best results, water-wettable powders have been next, and dusts have been least efficient. The dusts wash off more easily than the other two. If sprays have time to dry, they will not wash readily. The treatments will remain effective for about 10 days.

The U. S. Bureau of Entomology and Plant Quarantine in February 1950 recommended chlordane for grasshopper control; 0.5 to 1 pound per acre when applied as a spray and 0.75 to 1.5 pounds per acre when applied as a dust. In the bran-sawdust poison bait mixture 0.5 pound of chlordane may be used in place of 6 pounds of sodium fluosilicate.--Wakeland and Parker (358, 480, 481).

Blattidae

Blattella germanica (L), the German cockroach

Purified chlordane dissolved in a mixture of 4 volumes of reagent grade benzene and 1 volume odorless kerosene and tested for direct contact toxicity on 4th and 5th instar nymphs caused 100 percent mortality at 20 micrograms per square centimeter. The median lethal deposit (LD-50) was 1.7 micrograms per square centimeter.--Brown, Wenner, and Park (53).

When applied directly to adult female roaches chlordane gave 87 percent mortality when a 5.0-percent dust was used with a deposit of 3.0 micrograms per square centimeter. In container dusting a deposit of 0.5 micrograms per square centimeter of a 0.5-percent chlordane dust with a deposit of 0.75 micrograms per square centimeter gave a mortality of 90.0 percent. DDT and sodium fluoride were less toxic and gamma-BHC was more toxic than chlordane.--Niswander and Davidson (352).

When tested in the form of deposits, chlordane paralyzed roaches more quickly than DDT and toxaphene, but less quickly than gamma-BHC.—Hamman (202).

Residue tests were made by placing the insects on crystalline deposits of the compounds on filter paper, deposited from standard acetone solutions. Chlordane and gamma benzene hexachloride were about equal in toxicity and each was more than 1,000 times as toxic as DDT. A chlordane residue of 1.3 micrograms per square centimeter killed 70 percent of the roaches in 120 hours.—Metcalf (323).

Adult German and American cockroaches were placed for two hours on pieces of cotton twill cloth that had been impregnated with acetone solution of the test material at the rate of 200 mg. per square foot. Gamma benzene hexachloride was the best of the materials during the first week and was outstanding on 5-hour knockdown, but it had lost most of its toxicity by the 28th day. Chlordane was effective when fresh and was somewhat more lasting than the other materials, although it was not highly effective after 28 days. DDT and toxaphene did not give high kills from 2-hour exposures even when freshly applied. The American cockroach appeared to be somewhat more resistant than the German cockroach to gamma benzene hexachloride and chlordane, but showed less resistance to DDT. Chlordane and gamma benzene hexachloride sprayed at the rate of 100 mg. per square foot on the walls of kitchens infested with cockroaches (chiefly Blattella germanica with P. americana) eliminated a high proportion of the roaches, and the rooms did not become reinfested with this species during the subsequent observation period of 8 weeks. Solutions of chlordane and a mixture of chlordane and DDT, when dispersed by means of a thermal fog generator, effectively controlled cockroaches, but a similar treatment with DDT alone was much less successful.—Gahan et al. (162).

Chlordane should be applied at about 500 mg. per square foot. The apparent greater effectiveness of chlordane over DDT may be due to the persistent sticky nature of the material coupled with a slight fumigating property.--Kruse (269).

In laboratory tests chlordane at 2-percent strength in oil solution was more effective than a 10-percent DDT powder.--Gould (183, 184, 189).

Five gallons of a 2-percent chlordane emulsion applied with a Bes-Kil aerosol generator to a building gave practically 100 percent control, and only a few roaches had reappeared 4 months later.--Somsen and Munro (430).

Periplaneta americana (L.), the American cockroach

The relative toxicity of chlordane and DDT to the American roach was determined by applying precisely measured dosages to the thoracic tergites. Dosage mortality curves plotted from data obtained in these tests showed chlordane to be approximately three times as toxic as DDT to this insect. The LD-50 for chlordane was found to be approximately 14 micrograms per gram of body weight as compared to 38 micrograms per gram of body weight for DDT, when measured 120 hours after treatment. The corresponding values for LD-95 were approximately 25 micrograms per gram of body weight for chlordane and 70 micrograms for DDT per gram of body weight.--Kearns et al. (245).

When chlordane was added to a urea-formaldehyde surface coating (50-percent on the dry weight), it was more effective than DDT but less effective than gamma benzene hexachloride as measured both by the time to cause 50 percent knockdown and the time to produce 100 percent knockdown.--Block (36).

See also under Blattella germanica.--Cahan et al. (162).

The value of chlordane in controlling cockroaches has been demonstrated by pest-control operators and others. In general, practical tests have shown better results than those in the laboratory.--Knipling (265).

Chlordane has come into wide use against cockroaches. Its fumigating action plays a part in its effectiveness against cockroaches in hiding places.--Bishopp (32).

The dairy of Oregon State College remained free of cockroaches for 6 months after the application of a kerosene-chlordane space spray.--Fowler (152).

When tested in a dust chamber where a very small quantity of the test material was applied to a surface, a 5-percent chlordane dust killed all roaches in 3 days.--Lemmon (296).

Chlordane was recommended as one of the better insecticides for the control of roaches by the U. S. Bureau of Entomology and Plant Quarantine (472) in August 1949. Proper application of an insecticide is probably more important than the selection of the one to be used. Either powdered or liquid formulations will give satisfactory results.

Gryllidae

Gryllotalpa hexadactyla Perty, the American mole cricket

Chlordane was applied to turf as a 5-percent dust at the rate of one pound of actural chlordane to the area and watered in. There was an average of nine dead mole crickets on each plot of 100 square feet. The effectiveness of chlordane against mole crickets persists for as long as six weeks to two months after application. Death results from ingestion, contact, and fumigation.--Kelsheimer (250, 251).

Acheta assimilis F., the field cricket

A 5-percent chlordane dust applied at the rate of 1 pound of toxicant per acre reduced the population about 30 percent within 24 hours. A chlordane-bran bait applied at the same rate reduced the population 50 percent.--Munro et al. (339).

Nemobius fasciatus Deg., crickets

Crickets were more susceptible to chlordane than to DDT. A 0.05 percent chlordane dust killed 88.4 percent of crickets (nymphs and adults) in 2 days while a 1-percent technical grade DDT dust gave only 84.7 percent mortality.--Sun et al. (450).

Scapteriscus abbreviatus Scudd, the short winged mole-cricket

Wheat bran bait containing 1-percent of chlordane killed 100 percent of these crickets in 10 days. A 50-percent chlordane wettable powder at 4 pounds per 100 gallons of water per 1000 square feet of surface was also effective.—Hayslip (211, 212).

Scapteriscus acletus R. & H., the sourthern mole cricket

S. vicinus Scudd., the Puerto Rican mole cricket, changa

Chlordane kills much faster than does DDT. For seedbeds it is advised to use 50-percent chlordane emulsion at the rate of 1/4 pint to 100 gallons of water, applying this solution by means of a sprinkling can to 1,000 square feet of seedbed area. One application should be sufficient to give protection for at least two to three weeks. Two pounds of 50-percent chlordane wettable powder mixed with 50 pounds of wheat bran makes an efficient poison bait. Application is made in the late afternoon or evening. The killing power seems to be increased by rains or artificial watering.--Kelsheimer (250-252).

As little as 1/4 pound of chlordane as a 50-percent wettable powder in 100 gallons of water per 1000 square feet killed 95 percent of southern mole crickets in 8 days. A 5-percent chlordane dust at 60 pounds per acre killed 95 percent in 10 days. The dust was mixed with commercial fertilizer and applied to the upper 2 inches of soil.—Hayslip (211, 212).

Unidentified crickets

The University of Wisconsin (503) recommends chlordane for cricket control in the same dosage as used for grasshopper control.

ISOPTERA

Termitidae

Trinervitermes havilandi Fuller

When applied as 2.5-percent kerosene sprays to various surfaces the initial toxicities of DDT, BHC, and chlordane are of the same order but

DDT is much more persistent. BHC and chlordane become ineffective after 1 to 2 months, but the toxic effect of DDT is appreciable after 10 months. None of the three was very effective upon enameled surfaces. BHC caused a quick knockdown but if insects were then removed from treated surfaces, final mortality was often very low. Recovery after knockdown from DDT or chlordane was rare.--Petty (365).

Rhinotermitidae

Reticulitermes flavipes (Kollar), the eastern subterranean termite

Chlordane mixed with sandy soil, 1 to 20,000, remained toxic for 3 years.--Hetrick (216).

Unidentified termites

Soil treated with a 0.25-percent emulsion of chlordane remained toxic to termites 13 months after application in a test at Urbana, Illinois.--Shelford (417).

A second test, made one year after the first test, showed that the soil had lost no toxicity. Furthermore, there was no difference between samples from a 3 inch and an 8 inch depth.--Shelford (418).

THYSANOPTERA

Thripidae

Frankliniella fusca (Hinds), the tobacco thrips

In small plot tests at Baton Rouge and Bossier City, Louisiana in 1948, three applications of 10-percent chlordane dust at the rate of 10 pounds per acre at weekly intervals, beginning with the appearance of the first true leaf, gave satisfactory control. Although this treatment resulted in significant increases during the seedling stage in height and leaf surface of the treated plants as compared to the untreated checks, the differences were not reflected in yield between treated and untreated plants.--Newsom et al. (348).

Heliothrips haemorrhoidalis (Bouché), the greenhouse thrips

In laboratory tests with adult female thrips chlordane was less toxic than DDT, gamma-BHC, TEPP, and parathion; about as toxic as toxaphene; and more toxic than TDE and methoxychlor. A concentration of 0.0035 percent gave a fifty percent kill.--Metcalf (322), Metcalf et al. (325).

Scirtothrips citri (Moult.), the citrus thrips

Chlordane was not promising in tests in southern California.--Ewart (134).

Taeniothrips simplex (Mor.), the gladiolus thrips

For thrips on gladiolus chlordane dust is more effective than DDT dust but not as effective as the spray. During March and April when DDT sprays are not effective chlordane sprays give more satisfactory control especially where a severe infestation has developed.—Magie (309).

An emulsion of 0.5 pound of chlordane per 100 gallons of water applied 6 times at weekly intervals at the rate of 130 gallons per acre gave 94 percent clean flowers up to two weeks after the last application.--Smith (423); Smith and Boswell (424).

A 5-percent chlordane dust and a 50-percent chlordane wettable powder at 2 pounds per 100 gallons of water were very effective in killing thrips within the leaf folds and flower buds.—Magie and Kelsheimer (310).

Good control of thrips on gladiolus was obtained from the use of 5 percent chlordane dust.--Jenkins (241).

Thrips tabaci Lind., the onion thrips

When tested on potted onion plants in the greenhouse, a dust mixture containing 2 percent chlordane gave excellent control of the onion thrips.--Sun et al. (450).

In trials in Indiana in 1946, 2- and 5-percent chlordane dusts and a 5-95 DDT-sulfur mixture gave the greatest reduction in the thrips population.—Gould (186).

A pyrophyllite dust containing 5 percent of chlordane, applied at the rate of 10.5 pounds per acre, caused a 98 percent reduction in the number of thrips 24 hours after treatment and a 71 percent reduction 5 days after treatment. These tests were made on seedling cotton at Bayview, Texas in the spring of 1947 on 0.1 acre plots.—Fife et al. (137).

In 1947 in New Jersey, a 3-percent chlordane dust gave an outstanding reduction in thrips population and a fairly good increased yield of onions.—Pepper (362).

Chlordane emulsion spray, 1 pound per 100 gallons of water, gave promising results in 1947 in tests at Twin Falls, Idaho, causing a reduction of 77 percent in the population.—Douglass and Shirck (112).

Chlordane, applied as a dust at weekly intervals, gave very good control of thrips on onions, reducing the number to an average of less than 9 per plant, whereas the untreated plants averaged 31 thrips per plant throughout the season. The plants in all treated plots were larger and greener than those in the check plots.—Floyd and Smith (146).

ANOPLURA AND MALLOPHAGA

Chlordane has been tested against several species of sucking and biting lice and found to be highly effective.--Bushland (57); Bishopp and Knipling (34).

Tests with identified species have been reported as follows:

Anoplura - Haematopinidae

Haematopinus adventicius Neum., the hog louse

In one test with a few animals chlordane wettable powder spray at 0.2 percent concentration gave apparent complete control of hog lice.--U. S. Bur. Ent. and Plant Quar. (468).

Sprays containing 0.2 percent of DDT, TDE, or chlordane completely elimininated lice on hogs in tests made in Massachusetts in 1946. No irritation or harmful effects from the insecticides were observed. The chlordane acted most rapidly and the lice began to drop in a few minutes.--Sweetman (451).

Haematopinus eurysternus (Nitz.), the short-nosed cattle louse

Linognathus vituli (L.), the long-nosed cattle louse

A 0.5 percent chlordane suspension destroyed all short-nosed and long-nosed lice on heavily infested cattle in less than 8 hours, was nonirritating, and a single application was nontoxic to newborn calves.--U. S. Bur. Animal Ind. (465).

Tests on cattle against sucking lice of the species *Haematopinus eurysternus* and on goats against biting lice, *Bovicola* spp., indicate that the motile forms are killed with lower concentrations of chlordane than are required for DDT.--Knipling (264).

Linognathus setosus (Olf.), the dog sucking louse

No lice were found on dogs 24 hours after they had been dipped in a 0.42-percent technical chlordane emulsion.--Turk and Batte (460).

Anoplura - Pediculidae

Pediculus humanus corporis Deg., the body louse

Chlordane was found to be outstanding against the body louse, but less persistent than DDT or toxaphene.--Bishopp (32).

When impregnated in cloth or when employed in powder form, chlordane proved much more effective than DDT. It also acted faster than DDT, paralyzing lice in 3 hours as compared with 6 hours for DDT. When compared with DDT on the basis of persistence, 1-percent and 5-percent powders of the two materials were about equal - perhaps chlordane was slightly more effective. In washing tests, garments impregnated with DDT were more resistant to loss of effectiveness than were those treated with chlordane.—Knipling (264).

When applied to cloth and evaluated by the beaker test method, technical chlordane was effective at a concentration of 0.0005 percent. Lice exposed on cloths impregnated with 1 percent of insecticide were paralyzed within 3 hours by chlordane. Chlordane was about as long-lasting as DDT. Sleeves of cotton underwear cloth impregnated with 2 percent of the insecticides were compared for resistance to laundering. Toxaphene, which was the most effective treatment, remained lethal to lice after four 15-minute boilings in a 1-percent soap solution. DDT lasted almost as long and was superior to chlordane.—Eddy and Bushland (126).

A single dose of chlordane was administered orally to rabbits at a dosage of 300 mg./kg. When undiluted chlordane in a gelatin capsule was fed to the animal, the mortality of lice feeding on the rabbit was 16 percent after 4 days. When administered as a 10 percent solution in corn oil (5 mg./kg.) through a stomach tube, the mortality of lice was 60 percent after 2 days, but the rabbit died after 4 days. One rabbit receiving 300 mg. chlordane per kg. in corn oil died within 2 hours; another receiving 25 mg./kg. died within 3 hours.—Knipling et al. (266)

Mallophaga - Menoponidae

Eomenacanthus stramineus (Nitz.), the chicken body louse

Menopon gallinae (L.), the shaft louse

Mallophaga - Philopteridae

Goniocotes hologaster Nitz., the fluff louse

Dusts containing 2 or 5 percent of chlordane, applied at rates from 2 to 10 pounds per 100 square feet of soil, gave excellent results and were somewhat superior to the 3-percent DDT dust. The birds remained free of lice for 4 to 5 weeks.—Creighton et al. (87).

One application of 5-percent chlordane dust to the birds was less efficient than sodium fluoride, but gave satisfactory control up to 70 days after treatment. Pens treated with 2-percent and 5-percent chlordane sprinkled over the litter at the rate of 2 pounds per 100 square feet were still free from lice 70 days after treatment.—Edgar (130); Edgar et al. (131).

In laboratory tests in Kentucky excellent control of body, shaft, and fluff lice was obtained with one application of 5-percent chlordane powder on the bird.—Ky. Agr. Expt. Sta. (258).

Cuclotogaster heterographus (Nitz.), the chicken head louse

Lipeurus caponis (L.), the wing louse

Same as for Eomenacanthus stramineus.--Edgar (130); Edgar et al. (131).

Mallophaga - Trichodectidae

Bovicola caprae (Gurlt), the red goat louse, the goat biting louse

B. crassipes (Rud.), the yellow louse on goats

Chlordane and DDT are about equal in efficiency against the red and yellow goat lice. In a limited number of tests a 0.2-percent concentration of chlordane in dip form with either wettable powder or emulsion gave complete control which was maintained for at least 4 months.--U. S. Bur. Ent. and Plant Quar. (468).

B. equi (L.), the horse biting louse

Chlordane emulsion was better than chlordane wettable powder, which was better than DDT wettable powder. The LD-50 of chlordane in emulsion form was 0.043 percent. The sprays were applied to Shetland ponies by means of an electric hand sprayer.--Batte and Gaines (28).

Bovicola spp.

See under Haematopinus eurysternus.--Knipling (264).

HOMOPTERA

Aleyrodidae

Aleurocanthus woglumi Ashby, the citrus blackfly

The addition of 0.9 ounce of chlordane per gallon of light-medium emulsion oil which was applied as a 1.67-percent water emulsion did not enhance the toxicity of the oil to 1st, 2nd, and 3rd-instar larvae or to pupae.--Plummer and Shaw (368).

Chlordane in Velsicol AR-60 or kerosene exhibited low toxicity.--Woglum et al. (506).

Trialeurodes vaporariorum (Westw.), the greenhouse whitefly

When applied as dusts containing 1 percent of the toxicant, chlordane was less toxic (52.6 percent mortality) than gamma-BHC (97.8) or aerosol grade DDT (85.6) to adults.--Sun et al. (450).

Unidentified species

A 5-percent chlordane dust applied for the control of the serpentine leaf miner on asters controlled whitefly, but was inferior to a BHC dust (0.75 percent gamma content) for this purpose.—Jefferson and Pence (239).

Aphidae

Anuraphis persicae-niger (Smith), the black peach aphid

In Oregon a 2-percent chlordane dust killed only 18.5 percent of these aphids on peach trees.--Jones and Rosenstiel (244).

Aphis gossypii Glov., the cotton aphid, the melon aphid

In laboratory and cage tests at Waco, Texas in 1946, chlordane gave promising results against cotton aphids.--Harned (205).

At 10- and 20-percent concentrations chlordane dust was effective against cotton aphids, but not quite so effective as corresponding concentrations of toxaphene, or BHC (gamma isomer 5.75 percent).--Ivy and Ewing (237).

At Florence, South Carolina in 1947, 10- and 20-percent chlordane dusts gave good control of cotton aphid, but a mixture of 10-percent chlordane and 5-percent DDT permitted a build-up of aphids in one test.--Bondy (41).

A 5-percent chlordane dust did not affect the aphid population.--Arant (20).

At a dilution of 1 to 300 of an emulsion concentrate containing 20 grams of insecticide per 100 ml., chlordane was slightly less toxic than technical grade DDT to the melon aphid of various ages.--Sun et al. (450). In additional tests these workers (449) used the melon aphid as a test insect to evaluate different chlordane formulations.

Chlordane 25-percent emulsion at 1:400 was unsatisfactory in controlling aphids (chiefly this species) on celery in Florida in 1948. No injury to celery plants was observed.--Wylie (514).

Aphis fabae Scop., the bean aphid

Mixtures of nicotine and chlordane dusts tend to produce mortalities slightly exceeding those to be expected from similar joint action, but the differences may not be great enough to prove synergistic action. At the 50-percent mortality level nicotine is 1.49 times as toxic as chlordane; at the 90-percent level nicotine is 1.43 times as toxic as chlordane.--Sun (445).

In the form of a 1-percent dust chlordane was more effective than aerosol grade DDT against the bean aphid in greehouse experiments in which aphids of various ages were included in the mortality counts.--Sun et al. (450).

See under Epilachna varivestis.--Huckett (229).

Aphis spiraecola Patch, the spirea aphid

See under Macrosiphum pisi.--Kearns et al. (245).

Macrosiphum pisi (Kltb.), the pea aphid

In laboratory tests 10-percent chlordane was more toxic than 1-percent nicotine, and 2-percent chlordane was less toxic than 1-percent gamma-BHC.--Bishopp (32).

In parallel tests with chlordane and DDT, applied as aqueous dispersions to the spirea aphid and to the pea aphid, chlordane proved several times more toxic to these insects than DDT. The pea aphid is the less susceptible of the two species to both compounds.--Kearns et al. (245).

In laboratory tests 2-percent chlordane dust gave higher mortalities than aerosol grade DDT and toxaphene of the same concentration on adults of the pea aphid. In greenhouse and field experiments where aphids of various ages were included in the mortality counts, however, the results show that chlordane was less effective than technical grade DDT against the pea aphid.--Sun et al. (450).

A 5-percent chlordane high pressure aerosol gave 72 percent control of pea aphid in Virginia; DDT gave 94 percent control.--Anderson and Hofmaster (19).

Macrosiphum solanifolii (Ashm.), the potato aphid

Tests made in Wisconsin in 1946 with tribasic copper sulfate plus insecticide showed chlordane both as a dust and as a spray to rank below HETP, DDT, nicotine, and BHC.--Wis. Univ. (504).

Same as for M. pisi.--Sun et al. (450).

Myzus persicae (Sulz.), the green peach aphid

For the control of the green peach aphid on shade grown tobacco in Florida in 1947, chlordane at first gave an excellent kill, but later applications (perhaps of a different compounding) did not prove effective.--Wilson et al. (499).

In greenhouse experiments a 1-percent chlordane dust was more effective than a 1-percent technical grade DDT dust.--Sun et al. (450).

In Florida chlordane 40-percent emulsion at 1:400 showed promise, but was less effective than BHC, parathion, and DDT emulsion in combating these aphids on cabbages.--Hayslip (211).

Phyllaphis fagi (L.), the woolly beech aphid

A 50-percent chlordane wettable powder at 1 and 2 pounds per 100 gallons of water proved ineffective.--Kerr (260).

Phopalosiphums pseudobrassicae (Davis), the turnip aphid

A 5-percent chlordane-pyrophyllite dust in laboratory tests killed only 1.5 percent of these aphids on kale leaves after 24 hours.--Brooks and Anderson (48).

Same as for *M. persicae*.--Hayslip (211).

Rhopalosiphum rufomaculatum (Wilson), the green chrysanthemum aphid

In tests to determine the fumigant action of chlordane on apterous females, air currents had a marked effect on the toxicity. A 60-percent solution was tested at dilutions of 0.125 and 0.5 pound actual chlordane per 100 gallons. In still air 0.5 pound per 100 gallons caused a mortality of 87.9 percent to aphids exposed to the vapor; in an air current of 3.7 miles per hour the mortality was 35 percent.--Dustan *et al.* (121).

Sipha flava (Forbes), the yellow sugarcane aphid

In Louisiana in 1947 and 1948 chlordane gave nearly perfect control.--Dugas *et al.* (117, 119).

Cercopidae

Philaenus leucophthalmus (L.), the meadow spittlebug

Five- and 2-percent chlordane dusts at the rate of 20 pounds per acre gave almost complete control of spittlebug nymphs on strawberries and sweet clover in Wisconsin in 1947 and were more effective than a 5-percent DDT dust. On alfalfa a 5-percent chlordane dust was the most effective of all materials tested, including hexaethyl tetraphosphate, tetraethyl pyrophosphate, DDT, and BHC.--Chamberlin *et al.* (69).

In Michigan in 1947 mammoth clover dusted with 2-percent chlordane plus 3-percent DDT at the rate of 30 pounds per acre had 28 percent of the stems infested 7 days after treatment as compared to 42 percent infestation for 5-percent DDT and no infestation in plants treated with 0.36-percent gamma-BHC dust.--Pederson and Sherman (361).

Chlordane emulsion and wettable powder at 1 pound of toxicant per acre in 1948 killed about 2/3 of the nymphs, proving less effective than it did in the 1947 tests.--Chamberlin and Medler (68).

A 3-percent chlordane dust gave 93 percent control of meadow spittlebug on strawberries.--Wis. Univ. (503).

Chlordane controlled spittlebugs but was inferior to methoxychlor.--Wilson (500).

Cicadellidae

Circulifer tenellus (Baker), the beet leafhopper

In Utah chlordane dust, spray, and emulsion, applied four times at weekly intervals, beginning with date of planting and during the period of leafhopper movement, did not control the curly top disease of tomatoes because the leafhoppers fed upon the tomatoes, thus transmitting the disease before receiving a lethal dose.--Dorst and Peay (111).

Empoasca fabae (Harr.), the potato leafhopper

In Indiana in 1946 chlordane proved inferior to DDT.--Gould (188).

When compared as dusts 3-percent chlordane was inferior (50.6 percent mortality in 3 days) to 0.5-percent DDT (94.7 percent mortality).--Sun *et al*. (450).

Chlordane, when applied alone, seemed to have an attracting effect on the leafhoppers. One week after treatment the potato leafhopper population increased on chlordane treated plots 2.4 times the untreated and by the end of 4 weeks, increased 3.1 times. The plants in the chlordane plots yellowed and were stunted in sharp contrast to the untreated plots which were also seriously injured by the leafhoppers, but didn't sustain such high numbers. Chlordane, 1 pound per acre decreased alfalfa seed yield 25 percent, but the combination of 1 pound DDT plus 1/2 pound chlordane (the best treatment tried) increased the yield 102 percent.--Wilson (500).

Unidentified species

Some leafhoppers were killed by chlordane (3/4 or 1 pound per acre) applied for the control of grasshoppers.--Severin (414).

Cicadidae

Magicicada septendecim (L.), the periodical cicada

Chlordane spray, 6.4 gallons of 50-percent emulsion or 8 pounds of 50-percent wettable powder per 100 gallons of water, was ineffective even when the cicadas were caught in the spray fog and well covered.--Cutright (96).

In field tests in Virginia in 1948 the application of chlordane spray (3.75 pounds per 100 gallons of water) to apple trees and to the undergrowth and soil beneath the trees did not retard the emergence of cicadas. In laboratory tests cicadas in cages were sprayed directly with this same chlordane spray. After 24 hours 39 percent of the cicadas were still normal.--Woodside (510).

Coccidae

Coccus pseudomagnoliarum (Kuw.), the citricola scale

Chlordane was not promising in tests in southern California.--Ewart (134).

Parlatoria oleae (Colvée), the olive scale

A spray of 1 quart chlordane in 100 gallons of water plus 3 pounds of 15-percent parathion applied in November reduced the percentage of scale-infested olives from 96 to 67 in 11 months.--Stafford (436).

Pseudoccoccus maritimus (Ehrh.), the grape mealybug

Chlordane spray (2 pounds of 50-percent wettable powder per 100 gallons of water) caused 49.8 and 43.6 percent mortality one week after applications on May 19 and June 2.--Neiswander (343).

Delphacidae

Peregrinus maidis (Ashm.), the corn lantern fly

A 5-percent chlordane-pyrophyllite dust, applied 3 times to a total of 28 1/4 pounds per acre, gave a control of 62 percent of the flies.--Brooks and Anderson (48).

Psyllidae

Psylla pyricola Foerst., the pear psylla

Chlordane emulsion concentrate (50-percent), 16 ounces to 100 gallons of water, was comparatively ineffective in a single test. On pear trees in New York the number of nymphs per spur two days after application of this spray was 14.3 as compared to 28.2 on untreated trees and none on trees treated with tetraethyl pyrophosphate, 4 ounces plus 2 ounces of spreader per 100 gallons of water.--Hamilton (201).

Chlordane spray (1 and 1.5 pounds per 100 gallons of water) had an initial efficiency of 61.5 and 69.3 percent, whereas the best material tested, parathion, at 1 1/4 ounces per 100 gallons had an efficiency of 99.5 percent.--Carlson and Newcomer (65).

HEMIPTERA

Coreidae

Anasa tristis (Deg.), the squash bug

In a laboratory test a 5-percent chlordane dust caused 100-percent knockdown and 85.7-percent mortality of the bugs in 48 hours. A 2.5-percent chlordane dust was almost as effective, causing 95-percent knockdown and 75-percent mortality in the same time. In a field-cage test 5-percent chlordane caused 80.6-percent mortality.--Walton (483).

DDT was relatively ineffective as compared with chlordane when applied to the adult squash bug in the form of aqueous sprays as well as dusts.--Kearns et al. (245).

Leptocoris trivittatus (Say), the boxelder bug

A 2-percent emulsion spray of chlordane killed 97 percent of the insects within 48 hours and showed residual action.--Munro and Post (339).

Leptoglossus gonagra (F.), the citron plant bug

In Florida this bug was controlled by 30 to 40 pounds of a 5-percent chlordane dust per acre or 0.6 pound of 50-percent wettable chlordane per 100 gallons of water.--Thompson and Griffiths (454).

Lygaeidae

Blissus leucopterus (Say), the chinch bug

In tests made in Connecticut chlordane gave the best control, followed by DDT-sabadilla mixture and DDT alone. Chlordane, applied to an infested lawn as a 5 percent dust at the rate of 5 pounds to each 1,000 square feet, destroyed both adult and immature bugs in 24 hours and its residual action persisted for two to three months or longer.--Schread (406, 408).

See also under "Unidentified ants".--Kelsheimer (252).

Nysius ericae (Schill.), the false chinch bug

In small-scale tests 5 percent chlordane dust gave 100 percent kill in 48 hours.--Smith (425).

Oncopeltus fasciatus (Dall.), the large milkweed bug

Adults in battery jars were exposed to chlordane vapor. At the end of one day the mortality was 66.6 percent and at the end of two days it was 100 percent.--Dustan et al. (121).

See under Blattella germanica.--Brown, Wenner, and Park (53).

Miridae

Adelophocoris lineolatus (Goeze), the alfalfa plant bug

A. rapidus (Say), the rapid plant bug

Chlordane wettable powder and emulsion at 1 pound of toxicant per acre gave very good control of these insects in alfalfa in Wisconsin. In tests of spraying equipment very good control of forage insects was obtained at 30 to 40 pound pressures and 15 to 30 gallons per acre. The method of application appears to be secondary to dosage per acre of the toxicant.--Medler and Chamberlin (320).

Dicyphus minimus Uhl, the suckfly

A 5-percent chlordane talc dust was effective against suckfly on tomato in the lower Rio Grande Valley in 1949. Nine days after dusting the number of suckflies in 20 net sweeps was reduced from 601.7 on untreated plants to 7 on plants treated with the chlordane dust.--Wene (494).

Lygus elisus Van Duzee

In tests made on alfalfa plots in Arizona in 1947 and 1948 one pound of chlordane was almost as effective as 1.25 pounds of DDT. The average Lygus reductions were 91 percent with chlordane and 92 percent with DDT. Dusts, emulsions, and suspensions of chlordane were equally effective.--Russell (401).

Lygus hesperus Knight

A 5-percent chlordane dust was less effective than a 0.5 percent parathion dust.--Smith (425).

Same as for Lygus elisus.--Russell (401).

Lygus oblineatus (Say), the tarnished plant bug

Chlordane showed some promise against tarnished plant bug.--Bishopp (32); Gould (186).

In cage tests at Tallulah, Louisiana a 20-percent chlordane dust killed 60 percent of these bugs in one test and 66 percent in another test. The highest chlordane mortalities were caused by a dust containing 10 percent chlordane plus 2.5 percent parathion (98 percent kill) and by a mixture of 10 percent chlordane plus 5 percent DDT (84 percent kill).--Scales and Smith (403).

In laboratory tests a dust containing 1 percent chlordane killed 95.8 percent of the adults in 2 days, whereas a dust containing 3 percent aerosol grade DDT killed only 54 percent.--Sun et al. (450).

Chlordane did not give as good results as DDT and BHC, although a combination of this material with DDT showed promise.--Pederson (360).

In fields lightly infested with tarnished plant bugs chlordane, 1 pound per 100 gallons per acre, increased the yield of ladino clover seed 14 percent and DDT spray, 1 pound per acre, increased the yield 22 percent.--Medler and Chamberlin (320, 321).

In tests in Indiana in 1948 chlordane completely controlled the insects (tarnished plant bug and stink bug) causing catfacing of peaches. Sod areas around the orchard were sprayed and it was found to kill remarkably well for a period of two weeks or longer.--Marshall (315, 316).

Same as for *Lygus elisus*.--Russell (401)

Lygus spp.

Chlordane showed some promise against *Lygus* bugs on alfalfa and sugar beets.--Bishopp (32).

Amblytylus nastus (Kirschbaum)

Miris dolabratus (L.), the meadow plant bug

A 5-percent chlordane killed 96 percent of the former and 88 percent of the latter on Kentucky bluegrass.--Ky. Agr. Expt. Sta. (258).

Psallus seriatus (Reut.), the cotton fleahopper

In laboratory and cage tests at Waco, Texas during 1946 5-percent chlordane was very toxic to cotton fleahopper adults and nymphs, but a 1-percent dust was much less effective than the same concentration of DDT or toxaphene. Neither of these concentrations was as effective as a dust formulation of benzene hexachloride containing 0.575 percent of the gamma isomer.--Ivy and Ewing (237).

In Texas during 1947 a 5-percent chlordane dust, applied once at the rate of 12 pounds per acre, was effective (83.4 percent control).--Gaines and Dean (164).

Pentatomidae

Euschistus servus (Say)

Same as for *Nezara viridula*.--Riherd (391).

Euschistus spp.

In tests to control the catfacing of peaches in Virginia in 1948 chlordane spray, containing 2.5 pounds of 40-percent wettable powder per 100 gallons of water, gave some control, but was inferior to DDT and sabadilla.--Woodside (512).

Murgantia histrionica (Hahn), the harlequin bug

Laboratory tests on adult bugs indicated that the median lethal dose of a 10-percent chlordane dust was 5.1 pounds per acre. Chlordane and toxaphene were more toxic than DDT or sabadilla as 10-percent dusts. In cage tests a 10-percent chlordane dust caused 34.5 percent mortality 5 days after application.--Gaines and Dean (165).

Nezara viridula (L.), the southern green stinkbug, the pumpkin bug

In laboratory and cage tests at Waco, Texas chlordane gave promising results. A 20-percent chlordane dust was less effective than toxaphene against adults and nymphs.—Ivy and Ewing (237).

Five percent chlordane dust was effective.—Kelsheimer (248, 252).

A dust containing 10 percent toxaphene - 5 percent chlordane - 85 percent pyrophyllite was highly effective in controlling these stinkbugs on spring planted cowpeas on the Texas Gulf coast.—Riherd (391).

Unidentified pentatomidae

Chlordane gave no control of catfacing in Illinois peach orchards in 1947 when applied five or more times beginning with the shuck split stage. It was used at the rate of 1 pint of 61 percent concentrated emulsion per 100 gallons of water.—Chandler (72).

Tingidae

Corythucha cydoniae (Fitch), the hawthorn lace bug

Chlordane spray made by diluting a mixture of 1 part of chlordane, 1 part Triton X-100, and 2 parts xylene with water to a content of 0.12 percent chlordane was effective in controlling this lace bug on Pyracantha shrubs. A DDT spray of the same strength was slightly more effective.--Walton (483).

COLEOPTERA

Carabidae

Agonoderus comma (F.)

A 5-percent chlordane dust, applied lightly to the soil surface, killed 100 percent of these beetles in the soil after 120 hours. Corn seed treated with chlordane dust at the rate of 2 to 3 ounces per bushel was completely protected against beetle attack.--Johnson (243).

Unidentified species

Same as for Hypera postica.—Severin (414).

Chrysomelidae

Acalymma vittata (F.), the striped cucumber beetle

Diabrotica undecimpunctata howardi Barber, the southern corn rootworm,
the spotted cucumber beetle

In laboratory tests on the spotted cucumber beetle 5-percent chlordane dust caused 100 percent knockdown in 1 hour and 100 percent mortality in 7.5 hours. In field plot tests on sugar pumpkins infested with both species 5-percent chlordane dust gave 94.8 percent control.--Walton (483).

In laboratory tests a dust containing 0.5 percent of chlordane killed 100 percent of adult spotted cucumber beetles in 4 days. In greenhouse tests a 3 percent chlordane dust killed 75 percent of the beetles in 2 days and 97.7 percent in 4 days.--Sun et al. (450).

In Indiana in 1946 chlordane gave a fair kill of spotted cucumber beetles.--Gould (186).

In tests made in Wisconsin in 1946 HETP, BHC, and chlordane showed effectiveness ranging between that of 10-percent sabadilla and 1.25 percent DDT.--Wis. Univ. (504).

A spray containing 0.1 percent of chlordane made by diluting a concentrated emulsion was about as effective as a 4-percent DDT emulsion spray and somewhat less effective than a 0.1 percent benzene hexachloride emulsion spray in preventing injury to peanut pods at Beltsville, Maryland in 1947.--Dobbins and Fronk (108).

Chlordane at 4 pounds per acre was the best insecticide tried, reducing the percentage of plants damaged from 33 in the check to 2.5.--Kulash (277).

Three applications to peanut foliage of emulsions containing chlordane, at the rate of approximately 0.38 pound of the active ingredient per acre-application, gave significant control at Beltsville, Maryland, where the infestation was less severe than in southeastern Virginia. Seven applications of certain formulations were made to the foliage on small plots of peanuts at Holland, Virginia during the period June 19 to August 23 in order to obtain maximum control. The following formulations gave significant control: 5 and 10 percent chlordane dusts, and 0.5 and 1 percent of chlordane in emulsion form.--Fronk and Dobbins (159).

Chlordane, 5 pounds per acre, was mixed with 4-12-4 fertilizer. Twenty-four days after planting 6 percent of the plants in the chlordane plots were destroyed by the rootworm. Plants in the chlordane plot were much larger and greener from the time of emergence until the plants were waist high. The average yield of corn from this treatment was chlordane, 77 bushels per acre; fertilizer alone, 58 bushels per acre; and check, 49 bushels per acre.--Floyd and Smith (147, 149).

Epitrix cucumeris (Harr.), the potato flea beetle

In field tests chlordane emulsion (20 g. in 100 ml.) diluted 1 to 500 gave a control of 90.2 percent in 3 days.--Sun et al. (450).

A 50-percent chlordane wettable powder (1/4 pound toxicant per 100 gallons of water) was less effective than a micronized DDT wettable powder (1/8 pound toxicant per 100 gallons of water) in reducing flea beetle damage on potatoes. Chlordane produced significantly better yields than DDT in a field trial.--Turner and Woodruff (462, 463).

Epitrix hirtipennis (Melsh.), the tobacco flea beetle

A spray containing 1 pound of chlordane as a 50-percent wettable powder and 3 pounds of Fermate in 100 gallons of water gave 86 percent uninjured plants in tobacco plant beds as compared to 17 percent in the check and 99 percent in the bed treated with DDT spray. The chlordane did not injure the plants. On newly set tobacco this chlordane spray gave 65 percent reduction of the flea beetle population as compared to 98 percent reduction effected by a DDT spray. All materials were applied in the plant bed a few hours before the plants were pulled for transplanting.--Dominick (110).

Leptinotarsa decemlineata (Say), the Colorado potato beetle

Chlordane at 2 pints per 100 gallons of water (0.24 percent) killed 91.7 percent of the larvae 1 day after treatment. Chlordane-DDT emulsion (25 percent by weight of each) at 2 pints per 100 gallons of water (0.03125 percent of each) killed 92.1 percent of the larvae 1 day after treatment. The results obtained with chlordane were not significantly different from the kills obtained with DDT alone.--Kulash (270).

In laboratory tests a 1-percent chlordane dust killed 78.3 percent of the adults and 14.7 percent of last instar larvae in 4 days. In greenhouse tests a 1-percent chlordane dust killed 91.7 percent of the adults and 100 percent of last instar larvae in 2 days. In field tests a 1-percent chlordane dust killed 88.4 percent of the adults and 100 percent of 3rd and 4th instar larvae in 2 days.--Sun et al. (450).

In laboratory tests chlordane proved only 10 to 15 percent as effective as the gamma isomer of benzene hexachloride when tested on larvae. The insecticides were applied as dusts and sprays and the mortality determined after 4 days.--Raucourt (384); Raucourt and Viel (385).

Aqueous sprays of chlordane and DDT applied to potato foliage and later infested with third and fourth instar larvae of the Colorado potato beetle showed chlordane to be more toxic than DDT to this insect.--Kearns et al. (245).

Chlordane proved better than calcium arsenate and almost as good as DDT in Ontario in 1948. These three insecticides were more effective when used alone than when mixed with fungicides.--Doyle and Duncan (113).

Phyllotreta striolata (F.), the striped flea beetle

In greenhouse tests a 1-percent chlordane dust killed 100 percent of adult beetles in 1 day. In field tests a 1-percent chlordane dust killed 97.3 percent in 3 days and a dust containing 1-percent chlordane plus 0.25 percent rotenone killed 100 percent.--Sun et al. (450).

Coccinellidae

Epilachna varivestis Muls., the Mexican bean beetle

Dusts containing 2 or 3 percent of chlordane applied to lima beans permitted slight foliage injury by the Mexican bean beetle. Sprays containing 1 or 2 pounds of 50-percent wettable chlordane per 100 gallons of water gave similar results.--Huckett (229).

A 5-percent chlordane-pyrophyllite dust at 32 pounds per acre (3 applications) gave 42 percent control of the larvae in tests made at Norfolk, Virginia in 1947.--Brannon (43).

Dust mixtures containing various concentrations and proportions of chlordane and rotenone were tested on larvae of the Mexican bean beetle. According to the loose definition of synergism, the addition of chlordane to rotenone produced a synergistic action.--Sun (445).

In laboratory tests a 5-percent chlordane dust killed only 5 percent of the adults in 4 days and a 2-percent chlordane killed 84 percent of third instar larvae in the same time. In greenhouse tests 2-percent chlordane dust killed 95 percent of third instar larvae in 4 days. In field tests a 3-percent chlordane dust killed 51.1 percent of third and fourth instar larvae after 3 days.--Sun et al. (450).

Unidentified lady bird beetles

Same as for Hypera postica.--Severin (414).

Chlordane was the least destructive of the chlorinated materials to four species of lady beetles.--Newsom et al. (349).

Cucujidae

Oryzaephilus surinamensis (L.), the saw-toothed grain beetle

A 5-percent chlordane talc dust acted slowly on the adults.--Moretti (332).

Curculionidae

Anthonomus grandis Boh., the boll weevil

Many tests of chlordane for boll weevil control have been reported: in Alabama by Arant (20); in Louisiana by Gaines and Scales (170), Newsom et al. (347, 350), and Scales and Smith (403); in North Carolina by Kulash (271, 272, 275), and the North Carolina Agricultural Experiment Station (353); in Oklahoma by Stiles and Fenton (439), and Brett and Rhoades (46); in South Carolina by Bondy (41), Fife et al. (138), Rainwater (383), and Walker et al. (482); and in Texas by Ivy and Ewing (237), and Gaines and

Dean (164, 167, 168). In several states dusts containing 10 percent chlordane gave boll weevil control equal to that given by calcium arsenate, prevented build-up of aphids, and killed some weevils developing in fallen squares. In other cases very erratic results have been obtained. Conflicting results were obtained regarding the practical benefits of killing weevils in squares and bolls.--U. S. Bur. Ent. and Plant Quar. (466, 467).

In South Carolina a dust containing 10 percent of chlordane and 5 percent of DDT, applied at the average rate of 10 pounds per acre - application has been recommended by the state agricultural experiment station for the control of the boll weevil and other insects on cotton.--S. C. Agr. Expt. Sta. (431).

Reports from county agents in South Carolina on the value of chlordane, BHC-chlordane, and toxaphene-chlordane for cotton insect control have been summarized by Sparks (432).

Anthonomus signatus Say, the strawberry weevil

A 5-percent chlordane dust reduced injury 85.5 percent.--Christ and Driggers (77).

A 5-percent chlordane dust gave excellent control of this weevil on strawberries in Kentucky and doubled the yield.--Ky. Agr. Expt. Sta. (258); Ritcher (395).

In New Brunswick, Canada, chlordane proved less effective than DDT.--Maxwell (319).

Brachyrhinus ligustici (L.), the alfalfa snout beetle

In several field trials chlordane appeared promising for alfalfa snout beetle control and proved superior to the standard peanut shell bait.--Gyrisco et al. (200).

Brachyrhinus ovatus (L.), the strawberry root weevil

A 5-percent chlordane dust, applied at the rate of 10 pounds toxicant per acre to a block of 12-15 yeal old hemlock trees, killed all weevils within 3 weeks.--Schread (411).

Ceutorhyncus assimilis (Payk.), the cabbage seedpod weevil

In Washington a chlordane dust was inferior to a 0.5-percent benzene hexachloride dust.--Eide (132).

Chalcodermus aeneus Boh., the cowpea curculio

In Texas two applications of a 5-percent chlordane dust reduced the percentage of infested pods on Black Eye peas from 15.3 (untreated) to 4.0, and three applications reduced the infestation to 2.0 percent.--Wene (492).

A 5-percent chlordane at 25 to 30 pounds per acre, applied 3 times permitted 2 percent of Black Eye pea pods to be infested as compared to 15.6 percent in the check.--Wene (493).

Conotrachelus nenuphar (Hbst.), the plum curculio

Chlordane in the form of wettable powder, emulsion, and dust has been tested for the control of the plum curculio in Georgia by Snapp (428, 429), and Savage and Cowart (402); in Illinois by Powell et al. (372, 373), Chandler (70-75), and Weinman (487); in Indiana by Marshall (315-317), and Purdue Univ. (376, 378); in Kentucky by Ritcher and Armstrong (397, 257); in New Jersey by Driggers and Darley (114); in New York by Dean (100), and Dewey and Van Geluwe (102); in Pennsylvania by Cox (85); and in Virginia by Bobb (38), Bobb and Grayson (40), and Hough (226).

In general these tests have yielded promising results when 1 pound of chlordane per 100 gallons of water was applied. Chlordane appears superior to lead arsenate, but inferior to benzene hexachloride. Damage to peach foliage and fruit in Virginia by the application of a 40-percent chlordane wettable powder has been reported by Hough (226), but other workers report no injury.

In Ohio in 1949 cage tests involving a study of the speed of knockdown, lethal action, and residual toxicity of 13 organic insecticides to plum curculio were conducted. Treated peach foliage was exposed to adult curculios at aging intervals of 0, 5, and 10 days under insectary conditions and at 10 days under orchard conditions. The insecticides may be arranged in order of their decreasing speed of knockdown as follows: parathion, ethyl o-nitrophenyl thionobenzene phosphonate, ethyl p-nitrophenyl thionobenzenephosphonate, tetraethyl pyrophosphate, aldrin, heptachlor, chlordane, dieldrin, toxaphene, 2-nitro-1,1,bis(p-chlorophenyl) benzene, technical benzene hexachloride, refined benzene hexachloride, and DDT.--Rings (393).

Cylas formicarius elegantulus (Sum.), the sweetpotato weevil

In the form of bait (40 parts ground sweetpotato to 1 part insecticide) chlordane formulations (48-percent emulsion, 50-percent powder and undiluted) gave 7 day mortalities of 88, 90, and 76 percent. Applied as a dust 2-percent chlordane caused 97 percent and 25 percent chlordane caused 100 percent mortality but also caused some foliage injury when applied to plants in the greenhouse.--Harrison (206).

Tests made in Louisiana in 1948 showed that calcium arsenate applied weekly reduced the infestation of potatoes by the sweetpotato weevil to 1.6 percent; chlordane applied in the soil at planting time at the rate of 5 pounds per acre reduced the infestation to 1 percent; and chlordane in the soil followed by the calcium arsenate treatments at weekly intervals reduced the infestation to 0.2 percent. The potatoes in untreated plots averaged approximately 10 percent infestation. Chlordane did not adversely affect the flavor of the sweet potatoes.--Floyd and Smith (145).

Hypera postica (Gyll), the alfalfa weevil

Adult alfalfa weevils were killed by chlordane (3/4 or 1 pound per acre) applied for the control of grasshoppers.--Severin (414).

Chlordane spray (an an emulsion concentrate) at the rate of 2 pounds of toxicant per acre caused 45 percent mortality in 24 hours, 59 percent in 48 hours and 100 percent in 14 days. In the plot treated with chlordane no retardation in the new growth or vigor was noted.--Hastings and Pepper (208).

Protostrophus sp., ground weevils

Laboratory tests showed that 5-percent chlordane dust at the rate of 0.11 mg./sq. cm. (10 pounds per acre) caused 100 percent mortality in 72 hours.--Petty (363).

Pseudocneorhinus bifasciatus Roelofs, a Japanese weevil

Preliminary tests indicated that chlordane was likely to prove more effective than BHC, DDT, or arsenate of lead in controlling this weevil feeding on privet.--Allen (13).

Sitona scissifrons Say

In North Dakota in 1947 2-percent chlordane dust proved inferior to 5-percent DDT dust in controlling this weevil on peas.--Post et al. (371).

Sitophilus granarius (L.), the granary weevil

In laboratory tests in which the insecticide was dissolved in oil and this solution allowed to spread on filter paper and age 24 hours before placing the weevils on it, chlordane proved less toxic than DDT. The relative potencies of chlordane with respect to DDT at 95, 50, and 25 percent kill are 0.19, 0.50, and 0.74.--Stringer (444).

The adults of this weevil proved suitable as test insects for the bioassay of the content of chlordane in preparations of this toxicant. The method consists of exposing the weevils to deposits of the preparation and of the pure insecticide that it contains and comparing the median lethal deposits.--Krijgsman and Berger (268).

See under Musca domestica.--Brown et al. (52).

Trichobaris mucorea (Lec.), the tobacco stalk borer

A 5-percent chlordane dust was more effective than a 10-percent DDT dust in preventing egg laying 3 weeks after the last application. A chlordane spray (2 pounds of 50-percent wettable powder per 100 gallons of water) was less effective than BHC, but more effective than DDT and toxaphene in preventing egg laying. Chlordane was slower than BHC in killing the beetles caged with freshly sprayed foliage.--Woodside (511).

Tyloderma fragariae (Riley), the strawberry crown borer

Five percent chlordane dust killed 100 percent of the adults in laboratory tests and gave excellent results in field trials.--Ritcher (396).

Dasytidae

Astylus atromaculatus Bl., the Astylus beetle

In laboratory tests 5-percent chlordane dust killed all beetles in 72 hours when applied at the rate of 0.11 mg./sq. cm. (10 pounds per acre).--Petty (363).

Dermestidae

Attagenus piceus (Oliv.), the black carpet beetle

Woolen cloths impregnated with six chlorinated hydrocarbon insecticides at concentrations ranging from 0.5 to 3 percent by weight of cloth were exposed to larvae of the black carpet beetle for 28 days. The following mortalities were obtained: chlordane 75 to 100 percent; benzene hexachloride (6 percent gamma) 0 to 100 percent; toxaphene 25 to 52 percent; DDT 15 to 47 percent; TDE 3 to 14 percent; and methoxychlor 1 to 6 percent. According to the visual damage and frass weight noted during these tests, the greatest protection to woolen cloth was obtained with DDT, TDE, chlordane, methoxychlor, toxaphene, and benzene hexachloride in the order named. Washing and dry cleaning seriously affected the toxicity and the protective value of all the treated cloths, with the exception of those treated with DDT, which resisted one washing at all concentrations.--Laudani and Marzke (285).

Elateridae

Aeolus spp., wireworms

The results from one experiment made in Louisiana in 1947 indicate that most of the wireworm injury to fall-planted cane may be prevented by applying 400 pounds of dust containing 1 percent of chlordane per acre in the furrow with the seed cane at the time it is planted.--Bynum et al. (63).

Agriotes mancus (Say), the wheat wireworms

Chlordane gave good control at 2 to 4 pounds per acre where wireworm infestations were light but under heavy infestations 4 to 8 pounds were required.--Rawlins et al. (386).

Seed corn was treated with chlordane at the rates of 4 and 8 ounces of 50-percent dust per bushel. This treatment did not affect the germination, but proved ineffective against wireworms in both laboratory and field tests. Both field plots were severely injured.--Dogger and Lilly (109).

Conoderus vespertinus (F.), the tobacco wireworm

Chlordane was mixed with screened soil, broadcast on the plots, and disked into the soil 3 weeks before the tobacco plants were set out. Where chlordane at 2.5 pounds per acre was used, 55.7 percent fewer plants were injured than in the untreated plots; at 3.5 pounds per acre 70.5 percent fewer plants were injured. BHC was more effective.--Ky. Agr. Expt. Sta. (258).

Where damage from this insect is expected, add chlordane to transplanting water at the rate of 1/2 pound of 50-percent wettable chlordane powder to each 50 gallons of water. Use liberal amounts of water as as to wet the soil all the way to the top of the ridge around plants.--Nettles and Lewis (344); Kulash (276).

Conoderus spp.

Same as for *Aeolus* spp.--Bynum *et al*. (63).

Dalopius pallidus Brown

Same as for *Agriotes mancus*.--Dogger and Lilly (109).

Drasterius mellillus (Say)

Same as for *Agriotes mancus*.--Dogger and Lilly (109).

Horistonotus uhlerii Horn., the sand wireworm

Chlordane, 2.5 pounds per acre, proved highly effective in the control of the sand wireworm in large plot tests in 1948 in Louisiana.--Floyd (143).

Chlordane may be mixed and applied with fertilizer or sand in the row at planting time or broadcast over the field in the fall.--Floyd and Smith (148).

Limonius ectypus (Say)

In Ontario in 1947 chlordane at 0.25 pound per acre was inferior to the same dosage of BHC. Chlordane was not promising in protecting potatoes but gave an increased yield of corn.--Armand (24).

A 40-percent chlordane wettable powder at 2 pounds per 100 pounds of sugar beet seeds caused 2/3 of the larvae to be moribund and 1/3 dead in 6 weeks. In another test 1 percent of 50-percent chlordane wettable powder (based on weight of sugar beet seed) gave poor control. Of all chemicals tested lindane was the most promising.--Lange *et al*. (282).

Limonius mancus (Say)

Same as for *Agriotes mancus*.--Rawlins *et al*. (386).

Melanotus communis Gyll., the corn wireworm

Same as for *Agriotes mancus*.--Dogger and Lilly (109).

Melanotus spp.

Same as for *Aeolus* spp.--Bynum *et al*. (63).

Unidentified wireworms

Chlordane was tested against wireworms in lima bean fields in Orange County, California. It was applied April 20, 1947, at the rate of 10 pounds per acre and the beans were planted 10 days later. In August all treated plots were better looking than the untreated plots. Ethylene dibromide gave the best control against wireworms and nematodes of all materials tested (DDT, benzene hexachloride, chlordane, and ethylene dibromide).--Crosby (89).

In preliminary tests in California chlordane proved effective for the control of wireworms when used at the rate of 10 pounds of technical grade chlordane in 20 gallons of solvent (such as benzene) per acre. The material was drilled into the soil to a depth of 6 inches using 12 inch spacings in the same manner as ethylene dibromide.--Lange (281).

In Connecticut in 1947 chlordane applied as a wettable powder by the conventional potato sprayer resulted in excellent tobacco stands at 5 and 2 1/2 pounds per acre even in cases in which more than half of the plants in comparable control plots were down. There was no off-taste or impaired burning quality of cured tobacco leaves secured from these plots. Chlordane produced an off-flavor in potatoes but to a much milder degree than BHC.--Greenwood (195); Turner (461).

Chlordane was inferior to parathion and benzene hexachloride in controlling wireworms attacking newly planted sugarcane in Florida. When chlordane was mixed with fertilizer and applied immediately, good control was obtained.--Hayslip (210, 211).

Chlordane offers some promise in wireworm control. Apply as a dilute dust to the soil surface and then disc or harrow into the top four to six inches of the soil. Five pounds of chlordane is the usual dosage.--Kulash (276).

Meloidae

Decapotoma lunata Pall., C.M.R. beetles

In laboratory tests 5-percent chlordane dust killed all beetles in 24 hours when applied at the rate of 0.22 mg./sq. cm. (20 pounds per acre).--Petty (363).

Epicauta pennsylvanica (Deg.), the black blister beetle

In Indiana in 1946 chlordane proved ineffective against the black blister beetle.--Gould (186).

Scarabaeidae

Amphimallon majalis (Raz.), the European chafer

A mixture containing 15 percent of chlordane, 82.5 percent of ethylene dichloride and 2.5 percent "Tween 20" diluted with water, 5 to 20 ml. per gallon per square yard of soil, gave from 12.2 to 21.9 percent control of third-instar larvae of the European chafer three weeks after treatment of the soil plots.--Gambrell and Mason (171).

Anomala orientalis Waterh., the oriental beetle

Autoserica castanea (Arrow), the Asiatic garden beetle

Practical control of the oriental beetle was obtained with chlordane at 5.4 and 10.8 pounds to the acre and a mixture of DDT at 13 pounds, and chlordane at 5.4 pounds to the acre. In another test a 50-percent chlordane powder, applied dry with a patented turf duster, in April, at a rate to give 10 pounds of toxicant to the acre on a mixed population, gave full control of the new generation, which consisted largely of oriental beetle larvae, by October.--Adams (7).

Conostethus impressus (Goldf.)

In laboratory tests 5-percent chlordane dust killed only 6.6 to 16.6 percent of the beetles in 120 hours when applied at the rate of 0.22 mg./sq. cm. (20 pounds per acre).--Petty (363).

Cotinis nitida (L.), the green June beetle

Chlordane at 3 1/2 pounds per acre, worked into the soil to a depth of 3 inches, killed 26.5 percent of the grubs and at 5 pounds per acre it killed 38.9 percent of the grubs. A 5-percent chlordane dust and chlordane spray were ineffective against the adults in laboratory tests.--Ky. Agr. Expt. Sta. (258).

Cyclocephala borealis Arrow, the northern masked chafer

A 5-percent chlordane powder, applied to soil with a fertilizer spreader at rates of 5.4 to 21.7 pounds toxicant per acre, virtually eliminated all grubs on a golf course on Long Island. The chlordane was applied in May and observations made in October.--Adams (8).

Popillia japonica Newm., the Japanese beetle

Chlordane is very effective against Japanese beetle larvae and adults. The principal tests of chlordane against this beetle have been made in New Jersey by Fleming (139, 140), in Connecticut by Schread (405-410), and in Maryland by Langford and Squires (284).

In laboratory tests of treated soil against third-instar larvae 1 pound of chlordane per acre when freshly applied was as effective as 25 pounds of DDT. At the end of 8 weeks in the soil 2 pounds of chlordane were required to equal 25 pounds of DDT. In field tests 10 pounds of technical chlordane per acre reduced the larval population more rapidly and more completely than did DDT at 25 pounds per acre. In these tests the chlordane was applied as a 5-percent dust to the surface by means of a 3-foot fertilizer spreader.--Fleming (139).

All stages of the Japanese beetle in soil are killed by dipping balled or potted plants in an emulsion prepared by adding 1 fluid ounce of the following solution to 10 gallons of water:

	Percent by weight
Ethylene dibromide	13.0
Chlordane (technical)	6.5
Cellosolve (ethylene glycol monoethyl ether)	6.5
Tween 20	6.5
Isopropyl alcohol	67.5

--Chisholm and Mason (76); Mason and Chisholm (318).

Japanese beetle adults may be controlled by a 50-percent chlordane wettable powder used at the rate of 2 teaspoons to a gallon of water and applied to vegetation at weekly intervals during July and August. This dosage of chlordane is 1/2 that recommended for DDT.--Schread (405).

Chlordane as an emulsion was not as effective as DDT or benzene hexachloride from the standpoint of either knockdown or residual effect.--Langford and Squires (284).

Aldrin proved more toxic than chlordane against Japanese beetle grubs; 6 pounds of aldrin in 10 days gave greater grub reduction than 10 pounds of chlordane in two weeks.--Schread (410).

In tests made in Connecticut in 1946, 1947, and 1948 chlordane at 8 pounds per acre was effective against Japanese beetles at the end of 18 months.--Schread (409).

In 1949 the U. S. Bureau of Entomology and Plant Quarantine (469, 470) recommended chlordane for grub control where quick action is needed. Chlordane kills the grubs faster than either DDT or lead arsenate. Use 10 pounds of actual chlordane per acre in a dust or spray. A chlordane treatment should last at least 2 years.

Adams and Matthysse (9) of Cornell University recommend chlordane at the rate of 10 pounds per acre for the control of Japanese beetle grubs. Chlordane acts more rapidly than DDT, killing grubs in from 2 to 3 weeks after application. Indications are that its effectiveness will persist for a least 2 years.

Scolytidae

Hylastinus obscurus (Marsh.), the clover root borer

A 5-percent chlordane dust, applied at the rate of 2.5 pounds of toxicant per acre in May 1947 in New York, gave excellent control and a 1-percent chlordane dust at 2.25 pounds of toxicant per acre gave high control. None of the insecticides tested as sprays at the rate of 1 pound of toxicant per acre were satisfactory. Chlordane did not injury red clover.--Marshall et al. (314).

Chlordane dust at the rate of 2 pounds toxicant per acre gave 46.6 percent non-infested plants as compared to 30 percent in the untreated check. The clover hay at harvest time bore a chlordane residue of 2 p.p.m. Aldrin, dieldrin, and BHC gave the best (90 percent or better) controls.—Gyrisco and Marshall (199).

Tenebrionidae

Tribolium castaneum (Hbst.), the red flour beetle

Portions of insecticidal dusts, judged to be between 50 and 100 mg., were applied to counted groups of T. castaneum in 2 x 1 in. specimen tubes. The tubes were gently shaken to distribute the dust and were then stored under controlled conditions of temperature and humidity until the insects were inspected. The results show that a relatively small increase in concentration of poison in a dust results in a large increase in mortality. Frequently, a fourfold increase in concentration has resulted in a change from a very low to very high mortality. A 0.1 percent chlordane dust killed 99 percent of the beetles in 24 hours at a temperature of 75° F. and a relative humidity of 70 percent. Chlordane was about 5 times more toxic than toxaphene.--Lord (302).

Tribolium confusum Duv., the confused flour beetle

Larvae are more resistant than the adults to spray residues. Eggs and pupae of the confused flour beetle do not appear to be materially affected by exposure on surfaces that have been sprayed with residual sprays. Immature stages were exposed for 24 hours to deposits of DDT, chlordane, and gamma benzene hexachloride that had been applied to glass plates at the rate of 50 mg. per 1/4 square foot. Eggs hatched almost normally, the average percentage being 77 after exposure to DDT, 75 for chlordane, and 47 for gamma benzene hexachloride, as compared with 77 percent for the check. A residue of 200 mg. chlordane per square foot on a glass plate killed 100 percent of the adult beetles exposed to it for 24 hours in 18 days. The effectiveness of residual sprays decreased with the increase in the absorptiveness of the surface sprayed. Their effectiveness also varied with the chemical composition of the surface. On cement surfaces the duration of effectiveness of all spray deposits was very short. Pretreatment of cement with a sealer, magnesium-zinc-silicofluoride, greatly improved the efficiency of spray deposits. On freshly painted wood surfaces the type of finish influenced the effectiveness of the spray deposit. Cold-water and flat oil paint greatly reduced the effectiveness of the spray deposits but enamel did not. Water suspensions of wettable powders were absorbed less than other formulations, so that on absorptive surfaces, such as cement and cardboard and unpainted wood surfaces, they were more effective.--Cotton and Frankenfeld (81); Cotton et al. (83).

Chlordane formulated as an emulsion was sprayed on variously treated wood surfaces and flour beetles were exposed to the residues (200 mg. chlordane per square foot) for 6 hours. The mortality of the beetles 12 days after exposure was 100 percent on the unpainted surface, 30 percent on cold-water paint, 20 percent on flat oil paint, and 60 percent on enamel.--Cotton and Frankenfeld (82).

See under Musca domestica.--Brown et al. (52).

See under Blattella germanica.--Brown, Wenner, and Park (53).

LEPIDOPTERA

Aegeriidae

Melittia cucurbitae (Harr.), the squash borer

In experiments at Geneva, New York, control of the borer was obtained with a 5-percent chlordane dust.--Carruth and Howe (66).

Sanninoidea exitiosa (Say), the peach tree borer

In tests made in Virginia in 1947 and 1948 chlordane at 1 pound per 100 gallons of water was not so effective as DDT and had a relatively short period of residual killing.--Bobb (39).

Crambidae

Diatraea saccharalis (F.), the sugarcane borer

In Louisiana in 1946 poor control (51 percent) of the borer was obtained with a 5 percent dust of technical chlordane.--Ingram et al. (236).

In 1947 chlordane accounted for a significant increase in borer infestation following second generation dusting, due apparently to its injurious effect upon the natural enemies of this pest. At one location in Louisiana chlordane caused a loss in yield of 6.65 tons of cane per acre.--Dugas et al. (117).

Lymantriidae

Euproctis terminalis (Walk.), the pine brown tail moth

In laboratory tests a 5-percent chlordane dust applied at the rate of 10 and 15 pounds per acre was less effective than DDT, toxaphene, and lead arsenate.--Petty (363).

Olethreutidae

Carpocapsa pomonella (L.), the codling moth

In Illinois in 1946 one pound of chlordane per 100 gallons of water, either as a 50-percent wettable powder or as an emulsion, proved less effective than lead arsenate or DDT in controlling codling moth on apples.--Weinman (486).

An emulsion of chlordane (150 g. chlordane and 500 g. white oil in 100 liters of water) was almost as good as DDT (88 percent efficacy as compared to 95 for DDT) in the control of codling moth larvae on apples in France in 1947. There was no phytotoxic action.--Frezal (157).

Chlordane, 2 quarts of 20-percent concentrate in 100 gallons of water, proved less effective than lead arsenate against the codling moth in Virginia.--Hough and Hill (227).

In Indiana Steiner et al. (438)in 1948 reported that chlordane has proved of little value for use in control of the codling moth or other apple insects.

In tests to control the codling moth attacking Payne walnuts in northern California chlordane was found not only to be ineffective, but its use resulted in a marked increase in the codling moth infestation, which exceeded that which occurred in the unsprayed trees. One spray of chlordane, 0.5 pound per 100 gallons of water in 1946, resulted in 14 percent of the nuts being infested as compared to 7.05 percent infested in the check.--Michelbacher and Middlekauff (327).

Grapholitha molesta (Busck), the oriental fruit moth

Field tests on peaches in New Jersey showed chlordane to be inferior to parathion when applied as sprays for the control of second and third brood oriental fruit moth.--Driggers and Merrill (115).

In Virginia in 1947 chlordane was not effective in killing oriental fruit moth adults. Spray residues of the insecticide, however, were extremely toxic to Macrocentrus parasites and residual killing was noted for several weeks after application under favorable conditions.--Bobb (38).

Injury by third brood moths reached outbreak proportions in peach orchards in Kentucky where chlordane had been used. Bacterium pruni seriously affected 17.1 percent of the fruits in chlordane sprayed plots, and only 3.2 percent of the fruits in plots sprayed with the standard lead arsenate schedule.--Ky. Agr. Expt. Sta. (258).

Polychrosis botrana (Schiff.)

In France in 1947 chlordane was tested as an emulsion (150 g. chlordane, 500 cc. petrole, 10 g. emulsifier and 100 liters of water). Its efficacy according to Abbott's formula was 80 as compared to 85.9 for DDT.--Frezal (157).

Polychrosis viteana (Clem.), the grape berry moth

In tests made in the Erie grape belt of Pennsylvania a spray of chlordane (as a 50-percent wettable powder) at 0.75 pound of toxicant per 100 gallons of water was not effective and severely burned the foliage of the Concord grape.--Cox (84).

Phalaenidae

Phalaeninae

In tests made at Charleston, South Carolina a 5-percent chlordane dust, applied at the rate of 20-25 pounds per acre-application, was fairly toxic to the cabbage looper and Agrotinae, but relatively ineffective against the imported cabbageworm in two spring tests and one fall test. A 3-percent chlordane dust was not very toxic to either the looper or the imported cabbageworm in two spring experiments. A chlordane suspension spray and an emulsion spray gave good to excellent reductions of the looper and imported cabbageworm and were superior to a 3-percent chlordane dust when applied at comparable dosages of active ingredient. This dust mixture did not have good dusting qualities. Chlordane dusts usually proved inferior to DDT dusts of comparable strengths. No plant injury was noted from the use of chlordane on cabbage.--Reid and Cuthbert (387).

Agrotis orthogonia Morr., the pale western cutworm

Chlordane dissolved in benzene-kerosene mixture and applied in a spray tower was moderately toxic to the larvae.--Brown et al. (50).

Agrotis ypsilon (Rott.), the black cutworm

A bait containing 1.5 percent of chlordane, 5 percent of xylene, and 11 percent of oil in bran killed 67 percent of the cutworms after 48 hours in laboratory tests.--Brooks and Anderson (48).

A 5-percent chlordane dust, applied to fields in North Carolina at rates of from 20 to 100 pounds per acre, was of little value. Irish potatoes grown in chlordane-treated soil showed no off-flavor.--Kulash (278).

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Anticarsia gemmatilis (Hbn.), the velvetbean caterpillar

A low concentration of chlordane showed some promise for the control of this insect in Louisiana in 1946, but the next year it gave very little control after five days.--Dugas et al. (116, 118).

A 1-percent chlordane dust was less effective than 1-percent DDT and 1-percent gamma benzene hexachloride dusts in controlling caterpillars on alfalfa in Alabama in 1946. All dusts were applied at the rate of 15 pounds per acre. In 1947, 5-percent chlordane dust gave 68 percent control of the larvae on soybeans 48 hours after dusting at the rate of 25 pounds per acre.--Arant (21).

Cirphis unipuncta (Haw.), the armyworm

In preliminary laboratory tests chlordane was much less toxic than DDT.--Bishopp (32).

Heliothis armigera (Hbn.), the tomato fruitworm, the bollworm, the corn earworm

A field test on tomatoes made in Louisiana in 1946 showed 2-percent chlordane dust to be inferior to cryolite and calcium arsenate.--Floyd (141, 142).

A 5-percent chlordane dust gave controls of 41.6 and 38.7 percent in two tests on western Long Island in 1948. The effectiveness of chlordane was less than that of DDT, TDE, parathion, or methoxychlor.--Butler and Carruth (61).

Dusts containing 5, 10, and 20 percent of chlordane failed to give adequate control of the bollworm.--Arant (20); Kulash (271).

In laboratory and cage tests in Texas a 20-percent chlordane dust was less effective against the bollworm than DDT or toxaphene.--Ivy and Ewing (237).

In Texas during 1947 a 20-percent chlordane dust was as effective as calcium arsenate, but less effective than a 20-percent toxaphene dust or a 5-percent DDT plus 3-percent gamma benzene hexachloride sulfur dust in controlling bollworm.--Gaines and Dean (164).

An emulsion of chlordane atomized on corn ears showed promise against the corn earworm.--Bishopp (32).

In North Carolina in 1947 a 5-percent chlordane dust gave 40.4 percent clean ears as compared to 75.5 percent clean ears resulting from the use of 0.25 percent DDT in mineral oil. Of the untreated ears 27.0 percent were clean.--Kulash (273).

In Florida in 1947 a 5-percent chlordane dust and a 50-percent chlordane wettable powder at 2 pounds per 100 gallons of water were inferior to DDT and methoxychlor dust and sprays in controlling earworms on sweetcorn.--Kelsheimer (249).

In the Everglades area of Florida a 3-percent chlordane dust gave 6 percent of ears with no worm damage; a 5-percent DDT dust gave 39 percent; and 2.7-percent DDT in oil gave 100 percent. A 40-percent chlordane emulsion, 1 quart to 100 gallons of water, was about equal to DDT emulsion, but less effective than parathion (2 pounds of 15 percent wettable per 100 gallons of water) in preventing tomato injury by the tomato fruitworm.--Hayslip (211).

In laboratory tests 5 percent chlordane was slightly less toxic than DDT, natural cryolite, or 2 percent parathion.--Petty (363).

A 1-percent solution of chlordane in refined mineral oil (Saybolt viscosity 185-195 sec. at 100° F.) injected into tips of ears of Golden Cross Bantam sweet corn in southern California was slightly less effective than 1-percent DDT and TDE solutions. These materials all gave good control when applied as high pressure aerosols.--Anderson and Hashe (18).

In Louisiana in 1948 chlordane dust, applied 8 times at an average dosage of 12 pounds of dust per acre per application, failed to control insects on Mexican June corn planted August 13. The plants were more than 50 percent destroyed and no ears were produced.--Floyd (144).

A 5-percent chlordane dust gave less than 50 percent worm-free ears in tests with sweet corn in North Carolina. Cotton treated with 5 percent chlordane was as heavily infested with bollworms as untreated cotton.--N. C. Agr. Expt. Sta. (353).

In the Lower Rio Grande Valley of Texas a 5-percent chlordane dust (4 dustings at weekly intervals) gave 45 percent earworm injury as compared to 79 in the untreated plants. A spray of 4 pounds 50-percent wettable chlordane per 100 gallons of water gave 2-percent whorls with live larvae compared to 45-percent in the untreated.--Wene and Blanchard (495).

Heliothis ononis (Schiff), the flax bollworm

Chlordane dissolved in benzene-kerosene mixture and applied in a spray tower had very slight effect on the larvae.--Brown _et al_. (50).

Laphygma frugiperda (J. E. Smith), the fall armyworm

A 5-percent chlordane-pyrophyllite dust, applied 3 times to a total of 28 1/4 pounds per acre, gave a control of 98 percent of armyworms after 72 hours. A bait containing 1.5 percent of chlordane, 5 percent of xylene, and 11 percent of oil in bran killed 100 percent of the armyworms after 24 hours in cage tests, and 93 percent after 48 hours in field tests. Chlordane dust failed to control late fourth-instar larvae.--Brooks and Anderson (48).

In tests made on field corn at Norfolk, Virginia, in July 1948, a 3-percent chlordane dust reduced the number of worms 57 percent below the check in 24 hours and increased the percentage of uninfested plants above the check 46 percent in 24 hours and 61 percent in 48 hours. In another test in a pasture a 5-percent chlordane dust killed 62 percent of the armyworms. Parathion and DDT gave the best control.--Hofmaster and Greenwood (225).

Five percent chlordane dust was fairly effective in controlling the armyworm but affected the corn adversely.--Tissot and Kuitert (456).

Chlordane dust was effective against this insect on tomatoes in Florida.--Kelsheimer (248).

For the control of this insect attacking lawns in Florida it is recommended to use 2 pounds of 50-percent chlordane wettable powder per 100 gallons of water per acre or a 5-percent chlordane dust.--Kelsheimer (253).

Chlordane, applied as an emulsion to corn ears, imparted an odor noticeable at harvest time. Dusts gave unsatisfactory control, but chlordane emulsion (1 ml. plus 0.5 ml. of emulsifier, 20 ml. of white mineral oil and water to make 100 ml.) gave consistently good control of this species and the corn earworm in sweetcorn.--Blanchard and Chamberlin (35).

Chlordane wettable powder (50-percent) at 2 pounds per 100 gallons of water gave good control of fall armyworms in the buds of corn. A poisoned wheat bran containing 5 percent of chlordane also gave good control.--Hayslip (210, 211).

A 5-percent chlordane dust, applied at the rate of 10 pounds per acre to Ladino clover, killed 1/2 the larvae two days after dusting. No phytotoxicity was observed.--Kulash (274).

See also under "Unidentified ants".--Kelsheimer (252).

Peridroma margaritosa (Haw.), the variegated cutworm

In preliminary laboratory tests chlordane was much less toxic than DDT.--Bishopp (32).

Platysenta sutor (Gn.)

A 5-percent chlordane dust killed 24.2 percent of the larvae on celery in Florida in 24 hours.--Hayslip (211).

Prodenia eridania (Cram.), the southern armyworm

In laboratory tests a 1-percent chlordane dust killed 96.7 percent of medium larvae in 2 days.--Sun et al. (449, 450).

In fumigation action against larvae chlordane was superior to gamma-BHC and DDT, but in contact action and stomach action it was inferior.--Sun et al. (448).

Prodenia litura (F.)

On fourth-instar larvae chlordane was almost as toxic as was DDT (83.3 percent mortality as compared to 95 percent for DDT after 48 hours).--Frezal (157).

Trichoplusia ni (Hbn.), the cabbage looper

In field tests a 3-percent chlordane dust killed 62.6 percent of the larvae in 3 days, and a dust containing 1 percent chlordane plus 0.25 percent rotenone 52.7 percent.--Sun et al. (450).

In laboratory and cage tests at Waco, Texas, during 1946 a 20-percent chlordane dust was less effective than toxaphene.--Ivy and Ewing (237).

Same as for Pieris rapae.--Dills and Odland (105).

Unidentified species of cutworms

When fields of grain, grass, or alfalfa were sprayed or dusted with 3/4 or 1 pound of chlordane per acre, many species of cutworms were killed.--Severin (414).

To control cutworms in a prepared seedbed apply about 30 to 40 pounds of 5-percent chlordane dust per acre.--Granovsky (194).

Older cutworms are not controlled by chlordane.--U. S. Dept. Agr. Ext. Serv. (473).

Chlordane dust is recommended for control of cutworms attacking sweet-corn in Florida.--Kelsheimer et al. (256).

Pieridae

Colias philodice eurytheme Bdv., the alfalfa caterpillar

A 5-percent chlordane dust at the rate of 1.25 pounds of toxicant per acre reduced the number of caterpillars 52.8 percent in 48 hours and 65.3 percent in 96 hours.--Smith and Allen (427).

Pieris rapae (L.), the imported cabbage worm

In 1946-1948 a 3-percent chlordane dust gave 72.6 percent control, proving inferior to DDT and TDE.--Dills and Odland (105, 107).

In a field test chlordane dust proved superior to benzene hexachloride.--Brooks and Anderson (48).

In laboratory tests a 3-percent chlordane dust killed only 5.6 percent of last instar larvae in 2 days as compared to 79.2 percent killed by a 3-percent technical DDT dust. In field tests a 3-percent chlordane dust killed 59.4 percent of the larvae in 3 days; a 3-percent DDT dust killed 79.5 percent; and dust containing 1 percent chlordane plus 0.25 percent rotenone killed 85.1 percent.--Sun et al. (450).

Psychidae

Acanthopsyche junodi Heyl, the wattle bagworm

In laboratory tests a 5-percent dust of chlordane, applied at the rate of 5, 7, 9, and 10 pounds per acre, was markedly more effective than natural cryolite against first and second instar bagworms when applied to the leaves only or when both leaves and worms were dusted. Chlordane appeared to be slightly less effective than benzene hexachloride against the first two instars, and was less effective than cryolite for the older bagworms.--Petty (364).

Phycitidae

Acrobasis caryae Grote, the pecan nut casebearer

Chlordane 44-percent emulsion concentrate at 1 quart per 100 gallons of water, applied late in the summer, Central Texas, in 1947, was less effective than DDT or lead arsenate in preventing nut casebearers from going into winter quarters.--Nickels (351).

Elasmopalpus lignosellus (Zell.), the lesser cornstalk borer

In Louisiana chlordane at the rate of 2.5 pounds per acre proved much more effective than 10 pounds of DDT and produced a nearly perfect stand.--Dugas et al. (120).

Ephestia kuehniella Zell., the Mediterranean flour moth

See under Musca domestica.--Brown et al. (52).

Homalopalpia dalera Dyar, the papaya webworm

A spray of 0.05 percent chlordane reduced the percentage of webs with larvae to 14.4 as compared with 81.7 in the check 7 days after treatment, but 36 days after treatment the percentages were 30.4 and 44.6, respectively.--Wolfenbarger (507).

Pyraustidae

Desmia funeralis (Hbsn.), the grape leaf folder

In California in 1947 a dust, containing 5 percent of chlordane and 50 percent of sulfur, was less effective (9 and 27.4 larvae in rolls per vine in two tests) than a 50-percent cryolite, 5-percent DDT, and 40-percent sulfur dust (1.6 and 2.4 larvae in rolls per vine). The untreated check vines contained 35.8 larvae in rolls per vine.--Frazier and Barnes (154).

Loxostege similalis (Guen.), the garden webworm

In barrier and dusting tests a 5-percent chlordane dust gave the most promising results.--Walton (483).

In laboratory and cage tests at Waco, Texas during 1946 a 20-percent chlordane dust was less toxic than toxaphene, but the results were considered promising.--Ivy and Ewing (237).

See under "Unidentified ants".--Kelsheimer (252).

Phlyctaenia rubigalis (Guen.), the celery leaf tier

In preliminary laboratory tests chlordane was much less toxic than DDT.--Bishopp (32).

Pyrausta nubilalis (Hbn.), the European corn borer

Chlordane dust was promising in tests made in Maine but was not so effective as DDT and Ryania.--Hawkins and Thurston (209).

Chlordane spray gave excellent control in Ontario in 1947.--Wressel (513).

Sphingidae

Protoparce quinquemaculata (Haw.), the tomato hornworm

P. sexta (Johan.), the tobacco hornworm

Chlordane prepared as a 5-percent dust gave 73 and 30 percent kills, respectively, of these two species on tomato, while a 2-percent dust gave 91 and 43 percent kills. Chlordane in oil emulsion-form at 1:800 gave an excellent, but slow kill on the hornworms with 84 percent kill for sexta and 80 percent for the other species.--Gould (185, 187).

A 5-percent chlordane dust was the only material that controlled full grown larvae of P. quinquemaculata on tomatoes in Florida.--Kelsheimer (248).

In Ontario chlordane was less effective than DDT which gave good control of the tomato hornworm even at 0.72 pounds per acre.--Fox et al. (153).

Tortricidae

Argyrotaenia citrana (Fern.), the orange tortrix

In Oregon a 5-percent chlordane dust, applied to blackberries, gave 41.1 percent control; a 5-percent TDE dust gave 100 percent control. In another test a 5-percent chlordane dust gave 33.6 percent control - the poorest of all insecticides tested. A spray containing 4 pints of chlordane emulsion (44 percent chlordane) per 100 gallons of water gave 86.1 percent control which was increased to 91.4 percent when 4 quarts of oil were added to the spray. TDE gave the best control of the sprays tested.--Rosenstiel (399).

A chlordane spray (1 quart of 44 percent emulsion per 100 gallons of water) gave good control of the larvae of red raspberries in the Puyallup Valley, Washington, but exhibited phytotoxicity causing a general yellowing of the foliage. A wettable powder appeared to be safe.--Johansen and Breakey (242).

Argyrotaenia velutinana (Wlkr.), the red-banded leaf roller

Chlordane, 1 pound of 40-percent wettable powder per 100 gallons of water, proved unsatisfactory for the control of the first brood leaf roller in a Maryland apple orchard.--Graham (191).

In New York in 1948 chlordane as a 50-percent wettable powder proved worthless against second brood.--Glass and Chapman (179).

Chlordane is ineffective.--Rings (392).

Choristoneura fumiferana (Clem.), the spruce budworm

Chlordane dissolved in benzene-kerosene mixture and applied in a spray tower had very slight effect on the larvae.--Brown et al. (50).

Cnephasia longana (Haw.), the omniverous leaf tier

Chlordane, 1 quart of 46 percent emulsion per 100 gallons of water, gave negligible kill of the caterpillars on field grown asters at Palo Alto, California.--Pritchard et al. (374).

HYMENOPTERA

Apidae

Apis mellifera L., the honey bee

The effect of chlordane on the honeybee has been observed in California by Eckert (122-124) and Linsley and MacSwain (300); in Massachusetts by Butler and Shaw (62); in Texas by Weaver (484); in Utah by Knowlton (267); and in Washington by Eide (132).

Laboratory tests by Eckert (123) proved that chlordane is highly toxic to bees as a stomach poison, contact insecticide, and as a fumigant. When chlordane is fed to bees in a 20-percent sugar sirup, the approximate LD-50 is 1 microgram per bee. The residual action extends over a period of 3 or more weeks under laboratory conditions.

Later results by Eckert (124) showing the comparative toxicity of the newer insecticides to bees are presented in the following table:

Table 1. - The toxic effect of certain chemicals on honeybees

Chemical	LD-50 in 72 hours, micrograms per bee
Benzene hexachloride (90% gamma isomer)	0.15
Chlordane	1.21
Aldrin	0.25
TDE	16.0
DDT	4.6 (room temp.) 12.0+ (95° F.)
Hexaethyl tetraphosphate	0.29
Parathion	0.07
Tetraethyl pyrophosphate	0.75
Toxaphene	22.0

Eckert also observed that chlordane dusts have reduced the field force of colonies by from 50 to 80 percent when applied to alfalfa in bloom. Chlordane in oil (2.5 percent solution) caused the loss of brood and a portion of the bees when applied in hot weather as an oil spray to grass in front of 30 colonies. A quick removal of the affected colonies prevented much heavier losses. The bees apparently pulled the fumes through the hives by their ventilating operations.

The walls of a comb room were sprayed with a 5-percent chlordane suspension in water for the control of ants and one year later enough chlordane vapor was present in the room to kill bees within 36 hours.--Eckert and West (125).

In laboratory tests bees in cages were dusted with a pre-determined dose of insecticide at 40 pounds pressure. The dust was allowed to settle for 30 seconds after which the bees were immediately transferred to other cages for observation. The toxicity of 10 percent chlordane-40 percent sulfur varied greatly with the temperature. At temperatures below 76° F. chlordane was only slightly toxic, the MLD being 29.95 pounds per acre, but at 86° F. its toxicity increased greatly.--Weaver (484).

Chlordane does not repel bees, but is very toxic to them if applied while they are active in the field and remains toxic from 12 to 48 hours following its application depending on weather conditions. There is less damage to bee populations from chlordane when used as a spray than when used in the form of a dust.--Mont. Agr. Expt. Sta. (331).

Cephidae

Cephus cinctus Nort., wheat stem sawfly

A 5-percent chlordane dust at 20 pounds per acre permitted an average infestation of 65 percent as compared to 68 percent in the check plot.--Munro et al. (338).

Formicidae

Camponotus herculeanus pennsylvanicus (Deg.), the black carpenter ant

Chlordane is effective as a 5-percent dust and as a 50-percent wettable powder, using 4 ounces of toxicant per 1,000 square feet.--Schread and Chapman (412).

Formica exsectoides Forel, the Allegheny mound ant

The application of a 50-percent chlordane wettable powder at low dosage levels killed adults in 5 to 6 hours; eggs did not hatch and pupae produced no adults.--Schread and Chapman (412).

Formica fusca var subsericea Say, the silky ant

Formica pallida-fulva subsp. nitidiventris Emery

Chlordane controlled these ants working in open soil at the base of shrubs and in turf.--Schread and Chapman (412).

Iridomyrmex humilis Mayr., the Argentine ant

Chlordane dust was repellent to the Argentine ant for a considerable period of time. It makes an excellent barrier around their nests or when sprayed on the walls of a building or foundation of a house. Ants that come in contact with the dust immediately withdraw and soon disappear from that immediate area.--Eckert (123).

Diesel oil containing 2 percent of chlordane controlled Bermuda grass and Argentine ant around beehives in California without causing noticeable loss of bees. Both grass and ants later came back into the treated area.--Eckert and West (125).

Lasius niger alienus americanus Emery, the cornfield ant

One pound of 50-percent wettable chlordane per 1,000 square feet caused a 100-percent reduction in ant hills after 30 days.--Kerr (259).

For the individual spot treatment, one-eighth of a teaspoon of 50-percent wettable chlordane powder is placed in the center of each hill and watered thoroughly into the nest, using a four-gallon pressure sprayer with the spray nozzle removed, or using a watering can with the spreader removed. For the complete turf treatment, the entire area is impregnated with the material. The 50-percent wettable powder applied at the rate of four ounces to 1,000 square feet was found to be desirable from the standpoint of the economic and the residual value of the insecticide. The turf is then watered with 50 to 60 gallons of water to 1,000 square feet to obtain maxium penetration. This treatment has destroyed all ants and has given complete protection from reinvasion for a period of four to six weeks.--Schread (406); Schread and Chapman (412).

Lasius niger var. neoniger Emery

Same as for L. niger alienus americanus.--Schread and Chapman (412).

Monomorium minimum Buckl., the little black ant

Tests at the Savannah laboratory of the Bureau of Entomology and Plant Quarantine have shown chlordane to be less effective than DDT as a residual treatment, although in actual practice it has been reported to be highly effective in controlling ants in homes.--Knipling (265).

Pogonomyrmex badius (Latr.), the Florida harvester ant

Colonies in a typical Texas Gulf coast pasture in Florida were treated with a 5-percent chlordane dust. The treatments were made by applying approximately one ounce of the dust over the mound around the entrance to the nest by hand in such a manner that the ants leaving or entering the nest would have to pass through the insecticide. Each nest was treated five times during the test. At the end of 83 days no colonies had been eradicated.--Riherd (390).

A chlordane residue of 1.3 micrograms per square centimeter killed 30 percent of the ants in 120 hours.--Metcalf (323).

Pogonomyrmex barbatus var. molefacians (Buckl.), the Texas harvester ant

More than 300 colonies in pastures and yards in Oklahoma were destroyed by pouring one cup (about 200 ml.) of 3-percent chlordane solution into the opening of each colony. Carbon tetrachloride and 95-percent alcohol were satisfactory solvents. Other diluents such as petroleum oils or water suspensions have since been found to serve as well.--Brett and Rhoades (44).

Solenopsis geminata (F.), the fire ant

Same as for M. minimum.--Knipling (264)

Solenopsis saevissima var. richteri Forel, the imported fire ant

In Mississippi in 1947 chlordane was effective in laboratory tests and in treating mounds in the field. A 5-percent chlordane dust was much more effective than a 10-percent DDT dust.--Lyle and Fortune (304).

In Alabama the most effective treatment of individual ant hills was opening the mound and mixing insecticide with the soil in the mound. One-half pint of 2.5-percent chlordane emulsion spray or 2 ounces of 10 percent dust was highly effective when applied in this manner. Above 90 percent control of fire ants was obtained on area treatments when 2 or 4 pounds of chlordane as dusts or emulsion sprays was disked into the soil. Considerably less control resulted from dusts when the soil was not disked. Whether the dust was applied previous or subsequent to disking appeared to be of less importance than thoroughness of disking. Emulsion sprays were almost as effective without disking as when disking was done.--Eden and Arant (129).

Tetramorium caespitum (L.), the pavement ant

Chlordane does not have the disadvantage possessed by DDT of being detected by ants, and they readily cross an area treated with it and so are destroyed. The simplest method of using solutions of chlordane is to apply it with a cheap paint brush. Paint a band about six inches wide around the kitchen and pantry, and around any other areas known to be frequented by the ants. In experimental work some benefit has been derived in control of grease-loving ants by placing small containers of attractive materials such as peanut butter or chicken fat on the floor, and then painting a band of chlordane solution around the lure. Chlordane solution,forced under the baseboard by an automobile force oiler, controls the pavement ant and also larvae of the carpet beetle. Chlordane should be painted along the foundation sill so that the ants have to cross the treated areas.--Schmitt (404).

Wasmannia auropunctata (Roger), the little fire ant

Chlordane spray at 0.05 percent reduced the number of little fire ants to 4 per linear foot of guava tree trunk 3 days after application and 0.10-percent and 0.50-percent sprays reduced the numbers to 2 and 0. The number of ants was still zero 54 days after the application of the 0.50-percent chlordane spray and a spray of DDT, 3 pounds of 50-percent wettable per 100 gallons of water.--Wolfenbarger (507).

Chlordane spray was prepared by dissolving 8 ounces of the technical grade of the toxicant in one-half gallon of Number 2 fuel oil, adding 19 ml. of phthalic glyceryl alkyd resin to make a stock emulsion, and then diluting the emulsion with water to make 100 gallons. The spray was applied thoroughly with a power outfit to the tree trunks and larger lower branches. Approximately 4 gallons of spray was used per tree. The infestations was significantly reduced for a period of at least 12 weeks. Number 2 fuel oil alone at a strength of 0.5 percent was of no value.--Osburn (354).

Unidentified ants

As a spray, as a dust, or mixed with fertilizer, chlordane gives excellent control of ants at rates as low as one pound to the acre. It may also be used as a bait.--Kelsheimer (252).

In Florida a 2 1/2-percent chlordane dust resulted in 90 to 95 percent control of the common species of ants found in groves in the central part of the state; a 5-percent dust destroyed all treated colonies. A dust containing 2 1/2-percent chlordane and 10-percent DDT has also resulted in 100 percent control of ant colony. The best method of killing out a colony of ants around the base of a tree is to mix a small amount of chlordane dust with the top inch of soil where the ants are working and then sprinkle an additional amount over the top of the soil and around the base of the tree. The leaf eating or agricultural ants can be controlled by sprinkling the chlordane dust over the whole surface around the entrance to the nest.--Thompson and Griffiths (454).

A 2-percent spray of chlordane was recommended by the U. S. Bureau of Entomology and Plant Quarantine (471) in August 1949 for the control of ants. Apply it directly into cracks or openings from which ants are emerging, and onto the surfaces immediately surrounding those openings. Then they will have to crawl over the deposit of insecticide that remains. Chlordane spray can also be applied directly to the nests of ants.

A mixture of lindane and chlordane has been suggested to accomplish both quick kill of ants and to have long-lasting residual action.--Toffaletti (457).

Tenthredinidae

Macrocentrus ancylivorus Roh.

See under Grapholitha molesta.--Bobb (38)

DIPTERA

Agromyzidae

Liriomyza flaveola (Fall.), the serpentine leaf miner

A 5-percent chlordane dust gave the most effective field control of this insect attacking tomatoes in Florida.--Kelsheimer (248).

Sprays containing from 1 to 2.25 pounds of chlordane per 100 gallons and a 5-percent chlordane dust (7.5 pounds toxicant per acre) gave satisfactory control of this insect on field grown asters in southern California.--Jefferson and Pence (239, 240).

Chlordane 50-percent wettable powder at 2 pounds per 100 gallons of water was inferior to parathion and toxaphene against the serpentine leafminer attacking tomatoes in the Florida Everglades.--Hayslip (212).

In a large plot test in southern Florida in 1947 chlordane emulsion (81 percent) at 2.3 pounds toxicant per 100 gallons of water gave 97 percent control of the serpentine leaf miner on potatoes.--Wolfenbarger (508).

Liriomyza orbona (Meig.), the pea leaf miner

Five applications of a 5-percent chlordane dust, applied by means of a power driven duster at the rate of 26 pounds per acre for each application, gave 98 percent control. Laboratory tests using known deposits of chlordane, benzene hexachloride, DDT, and hexaethyl tetraphosphate indicated that chlordane was the most effective, killing 100 percent of the adult flies in 16 hours with a dosage of 2 micrograms per 10 square inches of surface.--Lange and Smith (283).

Calliphoridae

Callitroga americana (C. & P.), the screw-worm

Chlordane is among the most effective insecticides tested against screw-worm larvae.--U. S. Bur. Ent. and Plant Quar. (468).

Callitroga macellaria (F.), the secondary screw-worm

Phormia regina (Meig.), the black blow fly

At Kerrville, Texas, in 1947 sheep were infested by implanting the newly hatched larvae of several blow flies, principally these species on a very small piece of ground beef which had been rubbed into the wool on the animal's rump. On either the second or third day after implantation, depending on weather conditions and the development of the larvae, the infestation was treated. Each of the chemicals was used at a concentration of 2 percent. Chlordane and the gamm isomer of benzene hexachloride (83 percent pure) protected sheep against reinfestation for relatively long periods of time, but in these tests neither remained effective as long as toxaphene.--Graham and Eddy (193).

Phormia spp.

Chlordane is effective in protecting sheep from fleece worm attack.--Bishopp and Knipling (34); Laake (280); U. S. Bur. Ent. and Plant Quar. (468).

Cecidomyiidae

Phytophaga destructor (Say), the hessian fly

Chlordane dust was applied by airplane in September 1947 to Colorado wheat fields. This gave some control. Because of winds airplane dusting is not the proper means of application.--Colo. Div. Agr. (78).

Culicidae

Aedes aegypti (L.), the yellow-fever mosquito

A dilution of 0.2 p.p.m. chlordane in water killed 100 percent of the larvae in 48 hours; 0.063 p.p.m. killed 50 percent. DDT was more toxic, 0.05 p.p.m. killed 100 percent and 0.014 killed 50 percent.--Ginsburg (175).

Insects confined in a small screen-wire cage were exposed for 10 seconds in a 100-cubic foot cabinet in which chlordane dissolved in cyclohexanone had been sprayed 20 seconds previously. A 5-percent concentration of chlordane gave 15 percent knockdown in 30 minutes and 99 percent mortality in 24 hours. The calculated concentration giving 90 percent mortality was: gamma benzene hexachloride 0.4; DDT 1.0; chlordane 3; and toxaphene 27. When tested as residues on plywood surfaces at dosages of 50, 100, 200, and 400 mg. per square foot, DDT was the only one of these four compounds still causing high mortality of mosquitoes at the end of 36 weeks at all dosages.--Gahan et al. (162).

As a space spray chlordane is slightly more effective than DDT against house flies, but less toxic to yellow-fever mosquitoes. Chlordane, like DDT, is slow in its effect on insects. When compared on the basis of speed of kill, DDT was more rapid against mosquitoes. When evaluated from the standpoint of residual action against house flies, chlordane in dosages of 50 to 100 mg. per square foot of surface remained effective for 9 and 24 weeks, respectively, when the flies were exposed for 2 hours. Similar results were obtained with yellow-fever mosquitoes. In field tests in Florida, when applied by airplane or with ground equipment, DDT was more effective than chlordane in killing mosquitoes present at the time of treatment, and also exhibited longer residual effects.--Knipling.--Knipling (264, 265).

A single dose of chlordane was administered orally to rabbits at a dosage of 300 mg. per kg. When undiluted chlordane in a gelatin capsule was fed the animal, the mortality of mosquitoes feeding on the rabbit was 4 percent after 1/4 day. When administered as a 10-percent solution in corn oil (5 mg./kg.) through a stomach tube, the mortality of mosquitoes was 99 percent after 4 days, but the rabbit died.--Knipling *et al*. (266).

Aedes communis (Deg.)

A series of laboratory tests with various insecticides were made on fourth-instar mosquito larvae collected in mountain areas in Oregon. Identification of the several lots used showed 93 percent *Aedes communis*, 6 percent *A*. *hexodontus*, and 1 percent *Aedes* sp. The temperature ranged from 50° to 60° F. in the various tests. DDT, added as an acetone solution to 1 part in 600 million parts of water, killed about 85 percent of the larvae in 48 hours. DDT and gamma-BHC were about equally toxic, and toxaphene, chlordane, and methoxychlor were somewhat less effective.--Roth *et al*. (400).

Aedes sollicitans (Wlk.), the salt-marsh mosquito

Chlordane sprays applied both from airplanes and with ground equipment proved inferior to DDT as a larvicide.--Fluno *et al*. (150); Knipling (264).

Chlordane in fuel oil solution, applied by hand equipment in the fall of 1947 in Alaska at 1 pound per acre, gave 66 percent control of *Aedes* mosquitoes.--Travis *et al*. (459).

The effectiveness of prehatching treatments for the control of arctic mosquitoes was studied in 1947 and 1948 at Churchill, Manitoba, Canada. These treatments were applied before the spring thaw to snow and ice covering potential breeding areas. DDT, in a wettable powder (50 percent) and an emulsion, gave complete control of larvae at 0.1 pound per acre. Chlordane and methoxychlor were slightly and toxaphene considerably less effective than DDT.--McDuffie *et al* (307).

Aedes taeniorhynchus (Wied.)

Same as for *A*. *sollicitans*.--Fluno *et al*. (150).

Aedes spp.

Tests were made against Aedes mosquito larvae on 146 one-eighth to one-half-acre plots near Anchorage, Eklutna, and Gulkana, Alaska. Nineteen tests were also made against Culiseta larvae. DDT oil solutions were more effective than fuel-oil solutions of chlordane. Against Culiseta larvae DDT, in fuel-oil and in water emulsions, was superior to fuel-oil solutions of chlordane. Five-percent chlordane in fuel-oil at 0.2 pound toxicant per acre killed 62 percent of Aedes larvae in 48 hours; the same dosage of DDT killed 98 percent.--Gjullin et al. (178).

Studies were conducted at Ft. Churchill, Manitoba, Canada in 1947 and 1948 to compare the effectiveness of new insecticides against arctic species of Aedes mosquito larvae. Chlordane was less toxic in oil solutions than DDT, but gave comparable kills as emulsions at a dosage of 0.1 pound per acre. None of the materials at the dosages tested was effective against pupae.—McDuffie et al. (308).

Anopheles crucians Wied.

Same as for A. quadrimaculatus in residue tests in buildings.--Gahan et al. (162).

Anopheles quadrimaculatus Say, the common malaria mosquito

The residual toxicity of chlordane, DDT, and gamma benzene hexachloride was compared by applying emulsified xylene solutions of the compounds to the surface of wallboards, which were then exposed at intervals over a period of 16 weeks to adult Anopheles quadrimaculatus. The increase in time required to produce a 100-percent knockdown as the treated surfaces aged was used as an index of loss in effectiveness of the compounds, by volatilization, absorption, or other means. After 16 weeks of aging, the time required for gamma benzene hexachloride treatment to produce a 100-percent knockdown had increased by a factor of 10 over its initial knockdown time. In the same period the time required for the chlordane treatment to produce a 100-percent knockdown had increased by a factor of 3, whereas, that of DDT remained approximately constant. It would seen that of the three materials DDT will provide the most permanent toxic surface. It is believed that the loss in residual effect from chlordane and gamma benzene hexachloride is due to their greater volatility, the latter being the more volatile of the two. Preliminary volatility measurements indicate chlordane to be considerably more volatile than DDT. A series of tests made to compare the larvicidal properties of chlordane, DDT, and gamma benzene hexachloride to the larvae of Anopheles quadrimaculatus resulted in the conclusion that there was no significant difference in the three compounds when applied as acetone suspensions, emulsions, and dusts.--Kearns et al. (245).

At the Orlando, Florida laboratory of the Bureau of Entomology and Plant Quarantine it was found that the toxicity of chlordane was practically identical with that of DDT to larvae of the malaria mosquito (0.01 p.p.m. killed 98.3 percent in each case in 48 hours).--Bishopp (32); Knipling (265).

This species was somewhat more susceptible than Aedes aegypti to chlordane spray residues. Buildings sprayed with 2.5 percent chlordane in kerosene to give a deposit of 200 mg. chlordane per square foot remained almost free of mosquitoes for 2 or 3 weeks, whereas in the DDT-treated buildings the number remained very low for 15 weeks.--Gahan et al. (162).

Chlordane may be effective as a residual poison on wallpaper for three months under certain conditions. The type of surface for residual insecticide application is highly important. At the end of 29 weeks DDT was more effective than benzene hexachloride or chlordane applied on a beaver wall board. The toxicity of chlordane on clay was very low after one week. Chlordane, benzene hexachloride, and DDT were much more effective on wall board than on clay. Chlordane spray, 200 mg. per square foot, was ineffective a week after application on an all-metal shed.--Cutkomp (95).

The various insecticides in order of their residual effectiveness against adult A. quadrimaculatus mosquitoes and house flies over a 26-week period were DDT, benzene hexachloride, chlordane, toxaphene, and TDE (DDD). Chlordane was tested in three combinations: (a) a 5-percent chlordane kerosene emulsion prepared by diluting a 25-percent chlordane, 5-percent Triton X-100, kerosene concentrate 1:4 with water; (b) a 5-percent chlordane xylene emulsion prepared by diluting a 35-percent chlordane, 4-percent Triton X-100, xylene concentrate 1:6 with water; and (c) a 2.5 percent chlordane xylene emulsion prepared by diluting the 35 percent concentrate 1:13 with water. Application of 200 mg. chlordane per square foot was not satisfactory against adult female A. quadrimaculatus at the end of a 16-week period. A 100-mg. dosage was not satisfactory at the end of an 8-week period. Application of 200 mg. chlordane per square foot against adult house flies was satisfactory for at least 8 weeks, while application of 100 mg. was not satisfactory even at the end of 1 week.--Fay et al. (136).

Insectary-reared Anopheles quadrimaculatus mosquitoes were released in rooms which had been sprayed with insecticides at the rate of 200 mg. of the active ingredient per square foot. Chlordane, applied as a 5-percent xylene emulsion and as a 5-percent kerosene emulsion, compared favorably with DDT in initial knockdown, but displayed a shorter residual life. It was slightly more effective when sprayed as a kerosene emulsion than as a xylene emulsion.--McCauley et al. (306); Quarterman (380).

Culex pipiens molestus Forskal

A strain of this mosquito which was unaffected by contact with 0.2 mg. DDT per square centimeter on glass was sensitive to 1/2 this quantity of chlordane.--Mosna (334).

Culex pipiens var. pallens Coq.

Mosquito pupae were immersed in aqueous emulsions of toxicants made by diluting a solution of 3 parts toxicant, 15 parts solvent naphtha, and 12 parts sulfonated oil to varying concentrations. It was concluded that chlordane is about 9 times as toxic as p,p'-DDT at the LD-50; and about 5 times as toxic as p,p'-DDT at the LD-99.87.--Nagasawa (342).

Psorophora ciliata (F.)

P. confinnis (L. Arr.)

Same as for Aedes sollicitans.--Fluno et al. (150).

Unidentified mosquitoes

As a larvicide for anopheline and several species of culicine mosquitoes, chlordane generally proved inferior to DDT in both laboratory and field tests.--Knipling (264).

In laboratory tests chlordane proved highly toxic to the fourth-instar larvae of eleven species of California mosquitoes.--Michelbacher (326).

Hippoboscidae

Melophagus ovinus (L.), the sheep-tick, sheep ked

Chlordane sprays have given excellent control.--Knipling (264).

Puparia were dipped in 0.5 percent suspensions of insecticides and held at room temperature (67-80° F.) or at a constant temperature of 80° F. and a relative humidity of 50 to 70 percent. Chlordane caused little if any mortality of pupae. The addition of a wetting agent did not enhance the effectiveness of the materials.--Hoffman (221).

Sheep ticks exposed to 24 mg. chlordane per square foot at 70° F. suffered 65 percent mortality and at 90° F. they suffered 98 percent mortality.--Hoffman et al. (224).

A 0.125 percent chlordane emulsion was effective in dipping tests, but less effective when applied as a spray. A 2-percent chlordane dust gave poor control.--Tibbetts and Sorenson (455).

In tests at Corvallis, Oregon ticks collected from sheep were exposed on khaki wool patches that had been dipped in an acetone solution of the insecticide. After exposing the ticks for 30 minutes at 70° F., they were transferred to beakers containing bits of cheesecloth and kept at 70° to 80° and an average humidity of about 75 percent. Chlordane was one of the insecticides which failed to give 100 percent mortality in 24 hours on cloth treated at the rate of 25 mg. of insecticide per square foot.--Gjullin (176).

Dipping tests showed that 0.2 and 0.5 percent concentrations of chlordane caused complete or nearly complete control of sheep ticks during the entire 110-day period of the test. Wool samples collected from the treated sheep and exposed to houseflies showed a high degree of toxicity for chlordane at the 0.05 percent concentration. When Shropshire ewes in heavy fleece were sprayed with 2.7 quarts of 0.2 percent chlordane, not all the sheep ticks were killed.--Fairchild et al. (135); U. S. Bur. Ent. and Plant Quar. (468).

Hypodermatidae

Hypoderma lineatum (De Vill.), the common cattle grub

H. bovis (L.), the northern cattle grub

In Ashland County, Ohio, 23 insecticide formulations were tested on 94 animals for cattle grub control. A mixture of 5 percent chlordane and 95 percent linseed oil gave 54.5 percent mortality; a mixture of 5 percent chlordane, 5 percent water, and 90 percent lanolin gave 91.9 percent mortality.--Telford (453).

Emulsions and wettable powder sprays containing up to 1.5 percent chlordane, applied as a wash and with a high power sprayer, caused less than 20 percent mortality of the cattle grub larvae. Dusts containing up to 5 percent chlordane also proved ineffective.--U. S. Bur. Ent. and Plant Quar. (468); Bishopp and Knipling (34).

A spray containing 4 pounds of 50-percent wettable chlordane per 100 gallons of water and a spray containing 1 gallon of 15-percent emulsifiable chlordane concentrate per 100 gallons of water, were ineffective. The sprays were applied at 350 to 400 pounds pressure.--Furman and Douglass (161).

Preliminary laboratory work indicated that a 1.5 percent suspension of chlordane prevents the eggs from hatching. A spray containing 2 percent chlordane (as a wettable powder), applied 4 times at 2-week intervals to cattle, resulted in an average of 12.2 grubs per animal being removed as compared to 39.9 in the untreated check. The insecticides were applied with a power sprayer at a pressure of 300 pounds per square inch. Special care was taken to see that the entire surface of each cow's body was wet to the skin and an average of 5 gallons of spray material per animal was used. Three of ten cows sprayed with chlordane died after the fourth application and this treatment was discontinued.--Graham (192).

Muscidae

Hylemya antiqua (Meig.), the onion maggot

The common onion maggot, and the black onion fly, Tritoxa flexa Weidemann, were controlled successfully during 1948 in Minnesota by chlordane in large field plots of commercial onions and in the laboratory.--Granovsky (194).

Hylemya brassicae (Bouche), the cabbage maggot

At Corvallis, Oregon in 1947 a 5-percent chlordane talc dust applied to the soil at the rate of 27.5 pounds chlordane per acre was ineffective in preventing maggot injury to radishes, kohlrabi, broccoli, mustard, and rutabaga.--Crowell et al. (91).

Chlordane gave the best results against cabbage maggot in radishes of all materials tested. A dust containing 0.4 percent of chlordane permitted only 1.8 percent infestation, whereas untreated plants had an infestation of 52.4 percent. A spray containing 0.1 percent of chlordane permitted 4 percent average infestation, a better result than was obtained with BHC, toxaphene, mercuric chloride, and DDT.—Dills and Odland (104, 106).

At Puyallup, Washington, a 5-percent chlordane dust permitted 26.4 and 26.2 percent maggot infestation in broccoli two and four months after transplanting.—Stitt and Eide (440).

Hylemya cilicrura (Rond.), the seed-corn maggot

Seed treatment gives little promise as a control measure for the seed corn maggot. A 5-percent chlordane dust used as a soil treatment reduced maggot injury, but imparted a slight flavor to dried beans.—Ristich and Schwardt (394).

Chlordane at 5 pounds per acre mixed with 4-12-4 fertilizer was highly effective.—Floyd and Smith (147, 149).

Musca domestica L., the house fly

Although chlordane is somewhat more effective than DDT to house flies on the basis of initial killing action, it lacks the lasting effects of DDT. In laboratory tests surface treatments at the rate of 200 mg. per square foot gave complete or near complete kill of flies exposed for two hours as long as 28 weeks after treatment. DDT, however, was still completely effective after 36 weeks even at the low rate of 50 mg. per square foot.—Bishopp (33); Bishopp and Knipling (34); U. S. Bur. Ent. and Plant Quar. (468).

The relative toxicity of chlordane and DDT to the adult house fly was measured by the "large group" Peet-Grady procedure. Under the conditions of the tests it was found that 0.2-percent DDT or 0.05-percent solutions of chlordane are required to produce a 95 percent mortality in 24 hours. A median lethal concentration was estimated from probit-log dosage curves which indicated that a 0.06-percent solution of DDT or a 0.02-percent solution of chlordane would be required.—Kearns et al. (245).

Chlordane acts as a fumigant as shown by tests in which house flies were exposed to vapors from residual deposits.—Hoffman and Lindquist (222).

Chlordane was mixed with food and fed to larvae of Musca domestica, Tribolium confusum, Ephestia kuehniella, and the adults of Sitophilus granarius. The results obtained with chlordane and with gamma benzene hexachloride are very similar, both compounds showing median lethal concentrations of less than 50 parts per million to all four species.—Brown et al. (52).

The toxicity to house flies of surface coating containing chlordane was determined by painting the inside of a small box with mixtures of 20 percent of chlordane and 80 percent of urea-formaldehyde, nitrocellulose, or polymerized diolefins dissolved in a vehicle. The time for knockdown of flies placed in the box was greater for chlordane than for DDT in all three coatings.--Block (36, 37).

Flies confined in a small screen-wire cage were exposed for 2-minutes in a 100-cubic foot cabinet in which chlordane dissolved in cyclohexanone had been sprayed 30 seconds previously. A 5-percent concentration of chlordane gave 8 percent knockdown in 30 minutes and 100 percent mortality in 24 hours. The calculated concentrations giving 90 percent mortality were: gamma benzene hexachloride 0.17; DDT 1.0; chlordane 0.88; and toxaphene 4.9. In residue tests (10 mg./sq.ft.) chlordane was superior to DDT in kill of flies after 8 weeks.--Gahan et al. (162).

A mixture of 0.8 percent of Van Dyk 264 [N-(2-ethylhexyl)bicyclo-(2.2.1)-5-heptene-2,3-dicarboximide], 0.2 percent of pyrethrins, and 0.2 percent of chlordane in Peet-Grady tests gave a 10-minute knockdown of 99 percent and a 24-hour kill of 98 percent. It requires a concentration of 2 percent of Van Dyk 264 plus 0.025 percent pyrethrins to give satisfactory kill and knockdown of house flies. When 0.2 percent of DDT or chlordane was added, the concentration of the compound could be reduced to 1 percent and a satisfactory kill and knockdown obtained.--Hartzell (207).

Toxicity of insecticides expressed in terms of percent mortality or LD-50 may vary greatly in different laboratories and at different seasons of the year, even if the same equipment was used. Toxicity index, which is used as a relative value to express the toxicity of insecticides, is defined as the ratio between the LD-50 of a standard insecticide and the LD-50 of the test sample, multiplied by 100. The toxicity of technical chlordane to house flies, determined by the tunnel spray method of Roan and Kearns, varied from 154 to 190 (alpha chlordane = 100). The toxicity index of alpha chlordane (a stereoisomer of chlordane, m.p. 101-102.5° C.) was 6.5 (dieldrin = 100) or 12.1 (aldrin = 100).--Sun (447)

The effect of temperature on speed of knockdown and mortality of house flies exposed to residues of several chlorinated hydrocarbons was determined by exposing house flies (1) continuously at constant temperatures of 70° and 90° F. and (2) for predetermined periods (1 to 20 minutes) at 70° and 90° and then holding them for 24 hours at the same temperature at which they were exposed. At a dosage of 50 mg. per square foot chlordane required 100 minutes for knockdown at 70° F. and 63 minutes at 90° F.--Hoffman and Lindquist (223).

A deposit of 144 mg. chlordane per square foot of plywood panel killed 100 percent of NAIDM house flies exposed for 5 minutes.--Hansens and Goddin (203).

In 1948 in California a comparison of the chlorinated insecticide for fly control in dairy barns showed BHC to be the most satisfactory material for the replacement of DDT. Only the barn walls were sprayed - not the animals. Chlordane at 50 pounds per 100 gallons of water was slow in knockdown, gave an excellent clean-up, and lasted for from 1 to 4 weeks.--Dietz (103).

Insecticides were applied on various surfaces and exposed to different environmental conditions in several experiments to determine their residual toxicities to the house fly. DDT and gamma-BHC were initially the most toxic compounds. The other three materials were, in order of their diminishing toxicity, chlordane, Rothane D-3, and toxaphene. BHC gave the most rapid knockdown, followed by DDT, Rhothane D-3, chlordane, and toxaphene. Vapors from gamma-BHC were about three times as toxic to flies as those from chlordane; both were extremely toxic as fumigants. The order of persistence of the residual treatments was, from the most to the least, DDT, Rhothane D-3, toxaphene, chlordane, and BHC.--Bruce (54).

Cristol (88) in 1949 examined the hypothesis that the insecticidal activity of various polychloro insecticides is due in large measure to the ability of the compound to liberate hydrogen chloride at the site of action of the insecticide. The relative toxicities to the house fly of the various constituents of technical chlordane were as follows:

	Relative effective dosages (Technical chlordane = 0.01)
Heptachlor	.0043
Octachlor, active isomer	.0056
Octachlor, inactive isomer	.017
Nonachlor	.020

In reactions with 0.04 M ethanolic sodium hydroxide at 46° C. the insecticidally active octachloro isomer and the nonachloro compound reacted much more rapidly than the heptachloro compound which is the most effective insecticidally, showing that dehydrochlorination with alkali and insecticidal activity have no systematic relationship.

Gersdorff et al. (173) determined the relative toxicities of certain chlorinated hydrocarbons to the house fly when applied as space sprays using the Campbell turntable method. Crystalline chlordane was about two-thirds as toxic as technical chlordane which proved to be one-fourth as toxic as aldrin and heptachlor. None of the sprays made with the chlorinated compounds caused appreciable knockdown.

Organic insecticides in various concentrations and formulations were used to treat 154 dairy barns in New York in 1949. Chlordane emulsion, 6, 12, and 24 pounds of toxicant per 100 gallons of water, provided 4 weeks or more control of house flies in these barns which were heavily infested before treatment. A mixture of chlordane (6 lbs.) and DDT (3 lbs.) was more effective than either chlordane or DDT alone.—Pimental et al. (367).

Same as for Siphona irritans.—Bruce and Decker (56).

Same as for Anopheles quadrimaculatus.--Fay et al (136).

Resistant house flies

House flies that had developed a resistance to DDT were tested against other insecticides. The special stock was distinctly more resistant to all the materials tested than the regular colony. Although a few reversals occurred in the individual tests, none appeared in the final averages at any concentration. To obtain equal mortalities, approximately twice as much toxicant was required for the special stock as for the regular stock with DDT, chlordane, pyrethrum, and rotenone. These tests show that the method of selection resulted in the development of an unusually strong stock of flies rather than one having a specific resistance to DDT.--Wilson and Gahan (498).

In tests made in southern California in 1949 against resistant houseflies chlordane, applied as a 40-percent wettable powder at 50 pounds per 100 gallons of spray (approximately 2.5 percent), gave an excellent initial clean-up and in some cases residual action lasted up to one month. In other cases, however, reinfestation was very severe after one to two weeks. The rate of fly knockdown by chlordane is slower than that of DDT.--March and Metcalf (313).

In samples of flies obtained from seven localities in five states heavy deposits of wettable chlordane and methoxychlor were nonrepellent or even slightly attractive. Respraying of two barns with chlordane emulsions and two with suspensions of methoxychlor provided a high degree of control for several weeks.--King and Gahan (263).

Flies from 6 barns in New Jersey which had been sprayed with DDT exhibited resistance in laboratory tests to technical DDT and p,p'-DDT residues of 144 mg./square foot. All these resistant flies were killed in tests using residues of chlordane.--Hansens et al. (204).

Specimens of a wild population of house flies that had survived repeated residual-type applicaions of DDT in Ellenville, New York were captured and offspring were cultured in the laboratory through three generations. Tests were made to determine whether this line of flies was resistant to DDT and other new insecticides as compared with a laboratory line of flies whose ancestors had never been exposed to these insecticides. The results of these tests showed that flies of the Ellenville line were highly resistant to DDT and related compounds, but showed no resistance to certain unrelated chemicals. The results of the tests with technical chlordane are as follows: A total of 18 tests were made in which flies were exposed for 2 hours, 1 hour, 30 minutes, or 15 minutes to surfaces to which 144, 100, 70, or 14.4 mg. of the active material had been applied per square foot of surface. All flies exposed to surfaces to which the three larger concentrations had been applied were killed as were those exposed for 1 hour to a surface to which 14.4 mg./square foot had been applied. The percentages of mortality of flies of the laboratory and Ellenville lines exposed to the latter surface for 30 minutes were 100 and 94.4, respectively, and for 15-minutes exposures they were 95.6 and 60, respectively. The comparative rates of mortality for all tests in which 387 flies of the laboratory line and 459 of the Ellenville line were used, were 99.7 percent for laboratory flies and 98.5 percent for Ellenville flies.--Barber and Schmitt (26).

In another series of tests with technical chlordane against these same 2 lines of flies, five tests were made in which flies were exposed for 2, 5, 10, or 15 minutes to a surface to which 144 mg. of the active ingredient had been applied per square foot. Of the flies exposed for 2 minutes 97.6 percent of the laboratory line and 94.9 percent of the Ellenville line were killed. All flies of each line were killed when exposed for the longer periods to this residue. Of 210 flies of the laboratory line exposed to this residue an average of 99.5 percent were killed, and of 208 flies of the Ellenville line similarly exposed 99.0 percent were killed. Five tests were made in which flies were exposed for 15, 30, or 45 minutes or for 1 or 2 hours to a surface to which 14.4 mg. of the active ingredient had been applied per square foot. Of a total of 172 flies of the laboratory line exposed to these surfaces an average of 66.9 percent were killed and an average of 71.1 percent of 152 flies of the Ellenville line were killed by similar exposures.--Barber and Schmitt (27).

In Italy Bettini and Barachini (30, 31) reported that flies resistant to high doses of DDT (5.3 g./sq. m.) all died when they came in contact with chlordane and BHC.

The susceptibility or resistance of the various strains of flies studied was determined from data obtained by topical applications of the toxicant to the thorax of female house flies. Acetone solutions of the insecticides were used in all tests. The dosage-mortality data were used to calculate the LD-50 values in terms of micrograms of toxicant per gram weight of fly. The data indicate that the acquisition of tolerance for one insecticide contributes to tolerance for the others. The LD-50 of chlordane to the NAIDM strain of flies was 8.2 (DDT = 16.8); whereas to the flies that had become resistant to DDT (LD-50 = 18,728), the LD-50 of chlordane was 15.6 micrograms per gram weight of fly.--Bruce (55).

Two strains of flies (one laboratory reared, the other collected in the field) were exposed to residues of seven insecticides. The materials tested, in order of decreasing effectiveness to the non-resistant flies, were dieldrin, gamma isomer of benzene hexachloride, aldrin, DDT, chlordane, methoxychlor, and emulsifiable pyrenone. The field collected flies were 7 times more resistant than the laboratory reared flies to DDT. There was no detectable difference in the reaction of the two strains to dieldrin, gamma-BHC, aldrin, chlordane, and emulsifiable pyrenone.--Pimentel and Dewey (366).

In Denmark DDT-resistant and control flies reacted uniformly toward chlordane.--Keiding and Van Deurs (247).

In Italy flies resistant to DDT were somewhat more resistant to chlordane than were non-DDT-resistant flies.--Alessandro and Smiraglia (12).

Experiments with chlordane and other insecticides against DDT-resistant flies are critically discussed by Patrissi et al. (359).

Siphona irritans (L.), the horn fly

In laboratory knockdown tests against the hornfly small screen-wire cages were dipped in preparations containing 0.5 percent of different chlorinated hydrocarbon insecticides. The methoxychlor caused complete knockdown in 5 minutes, DDT in 8, TDE in 17, chlordane in 53, and toxaphene in 73 minutes in tests made 24 hours after the cages had been dipped. After 2 months' exposure the methoxychlor, DDT, TDE, toxaphene, and chlordane caused complete knockdown of flies in 12, 62, 152, 248, and 360 to 720 minutes, respectively. The cage treated with methoxychlor apparently lost little of its effectiveness. The knockdown of flies exposed to animals treated with the insecticides was the same as that determined in the laboratory, except that a longer time was required.--Eddy and Graham (127).

Chlordane has been tested on animals exposed to horn flies in cages, and in field tests on dairy animals in Texas and beef animals in Kansas. Wettable powder sprays at concentrations of 0.25 and 0.5 percent chlordane (applying an average of approximately 2 quarts per mature animal) have given good control of horn flies. The two concentrations protected animals for about 3 and 4 weeks, respectively. Chlordane was slightly inferior to DDT for the control of horn flies.--Bishopp and Knipling (34); Cuff (92); Laake (280); Smith (421); U. S. Bur. Ent. and Plant Quar. (468).

In Illinois chlordane emulsion was as effective as DDT and TDE (DDD) emulsions in controlling these flies on milk cows.--Bruce and Decker (56).

Stomoxys calcitrans (L.), the stable fly

The speed of knockdown and kill and the duration of effectiveness of 11 of the more recently developed organic insecticides were studied in laboratory tests against the stable fly. Two 14-mesh copper-wire cages were dipped in a 1 percent solution of each test material in acetone. One cage was held indoors while its duplicate was stored outdoors, fully exposed to the effects of the weather. In the tests made 24 hours after the cages were treated, DDT and methoxychlor proved to be the fastest acting compounds and toxaphene and chlordane the slowest acting. From the standpoint of knockdown and duration of effectiveness, methoxychlor and the bromine analog of DDT appeared to be superior to any of nine other compounds tested, including DDT. Parathion, aldrin, and toxaphene appeared to retain their toxic properties longer than did TDE, gamma-BHC (95%), compound 153, heptachlor, or chlordane.--Eddy and McGregor (128).

Chlordane, as a 2-percent water suspension made from a 50-percent wettable powder, proved equal to DDT in the control of house flies and stable flies.--Muma and Hixson (335).

Same as for Siphona irritans.--Bruce and Decker (56).

Psychodidae

Psychoda alternata Say, the filter fly

In June 1949 filter flies, which had become tolerant to DDT, proved susceptible to chlordane. However, the third and fourth chlordane treatments were considered failures. This served again to illustrate the rapid acquisition of insecticide tolerance by insects through the treatment of the larval habitat, the filter bed.--Bruce (55).

Sarcophagidae

Many species of flies, including Sarcophagidae, were killed by chlordane 3/4 or 1 pound per acre, applied for the control of grasshoppers.--Severin (413).

Simuliidae

Simulium latipes Fries

S. venustum Say

S. vittatum Zett.

In tests in Alaska a chlordane-acetone suspension was not effective against larvae at 0.5 p.p.m.--Gjullin et al. (177).

In Alaska chlordane proved inferior to DDT, TDE, and methoxychlor for the control of black fly larvae.--Travis (458).

Chlordane was tested in the form of a 25-percent emulsion concentrate with 65 percent xylene and 10 percent Triton X-100, also as a 10-percent solution in Velsicol AR-50 and fuel oil. Chlordane in fuel oil, at 1.185 p.p.m./min., or 1:12,700,000 for 15 minutes, gave partial control for a short distance from the point of application.--Hocking et al. (220).

In flume tests on larvae of a black fly, Simulium venustum Say, made in the summer of 1947 in the White Mountains of New Hampshire, chlordane did not cause 100 percent detachment at 4 p.p.m.--Kindler and Regan (261).

Tabanidae

Tabanus sulcifrons Macq.

Chlordane is ineffective in protecting animals from attack by horse flies.--Bishopp and Knipling (34); Knipling (264).

Chlordane as a 10-percent solution in a mixture of Number 1 fuel oil and cyclohexanone was applied at the rate of 2 pounds of toxicant per acre by a plane which flew at 5 to 20 feet above the tree canopy. The effectiveness of the material was determined by counting flies attacking draft horses led through the test plots 1 day before spraying and 1, 2, 3, 5, and 7 days after treatment. The results appeared somewhat erratic and no appreciable effect on fly populations could be demonstrated for any of the insecticides tried. Tabanus abactor and T. sulcifrons were the two most abundant species. T. atratus, T. vittiger, T. mularis, and T. venustus were present in small numbers. A few species of Chrysops and Silvius were also present.--Howell et al. (228).

Chlordane continues to kill tabanids feeding on livestock for about one day after treatment.--U. S. Bur. Ent. and Plant Quar. (468).

Trypetidae

Dacus tryoni Frogg., a fruit fly

In New South Wales, chlordane proved inferior to DDT, benzene hexachloride, and tartar emetic for the control of this fruit fly on plum. The chlorinated insecticides were applied as diluted emulsions containing 0.2 percent of the toxicant at fortnightly intervals at the rate of about 1 gallon per tree. Sugar at the rate of 1 pound per 10 gallons of spray was included with all three chlorinated insecticides to encourage feeding by the flies. The bait spray consisted of 2 ounces tartar emetic and 2.5 pounds of sugar in 4 gallons of water, applied at the rate of nearly 9 fluid ounces per tree. At harvest the percentages of undamaged fruits were 93.8 for tartar emetic, 92.3 and 85.9 for the two DDT sprays, 69.7 for benzene hexachloride, and 56.1 for chlordane.--Allman and Friend (14).

Rhagoletis cingulata (Loew), the cherry fruit fly

R. fausta (O. S.), the black cherry fruit fly

Chlordane, 50-percent wettable powder at 1 pound of toxicant per 100 gallons of water, greatly reduced the infestation, but failed to meet the requirement of 99.5 percent of maggot-free fruit.--Cox (86).

Rhagoletis pomonella (Walsh), the apple maggot

In laboratory tests at the New York Agricultural Experiment Station in 1947 chlordane showed a high degree of toxicity. The rate of kill at the higher dosage levels was more rapid than with DDT, although the knockdown rate was slower.--Dean (99).

SIPHONAPTERA

Pulicidae

Ctenocephalides spp.

When dogs were dipped in a 0.42-percent technical chlordane emulsion all fleas were dead in 1 hour. No fleas were found at the end of 24 hours on cats similarly dipped. Redipping these cats 7 and 23 days later caused no bad effect.--Turk and Batte (460).

ACARINA

Ixodidae

Amblyomma americanum (L.), the lone star tick

Chlordane dips at concentrations of 0.25, 0.5, 0.75, and 1.5 percent gave complete or nearly complete control of the flat stages on goats and cattle and 0.75 and 1.5 percent concentrations caused nearly complete kill of all stages. DDT on the same basis failed to kill all of the engorged forms at 1.5 percent concentration. The two insecticides were about equal in preventing reinfestation.--U. S. Bur. Ent. and Plant Quar. (468).

In preliminary tests at Camp Bullis, Texas, against the lone star tick dusts, applied at the rate of 1 to 2 pounds of chlordane per acre, were superior to DDT dusts applied at the same rate. A wettable powder and an emulsion containing chlordane when applied as sprays to infested cattle at concentration ranging from 0.25 to 1.5 percent chlordane also proved more effective than DDT against the same tick. The two materials, however, appeared to be about equal on the basis of duration of effectiveness against reinfestation.--Knipling (264).

In tests in Florida chlordane proved promising against the lone star tick when applied as a dust to infested areas, and it appeared to be superior to DDT for this purpose.--Knipling (265).

Dipping dogs in a 0.42 percent technical chlordane emulsion killed all ticks except a few engorged females.--Turk and Batte (460).

Boophilus microplus (Canestr.)

Four cows were sprayed with a 0.25 percent emulsion of chlordane every 28 days. No female adult ticks reached maturity on these cows although they were exposed to heavy larval infestation.--Legg (286).

Dermacentor albipictus (Pack.), the winter tick

Chlordane shows a distinct superiority over DDT against the winter tick on cattle and horses. Nearly complete control of all stages has been obtained with sprays at concentrations of 0.75 percent chlordane, whereas DDT at 1.5 percent killed only a small percentage of the engorged forms. From the standpoint of protection against reinfestation chlordane is also superior to DDT, At 0.5 and 0.75 percent chlordane prevents reinfestations for about two months as compared with one month for DDT at the same concentrations. Chlordane as a 5-percent dust has also given good control of winter ticks and proved superior to DDT.--Bishopp and Knipling (34); U. S. Bur. Ent. and Plant Quar. (468).

Dermacentor variabilis (Say), the American dog tick

Same as for Amblyomma americanum.--U. S. Bur. Ent. and Plant Quar. (468).

Dermanyssus gallinae (Deg.), the chicken mite

Dusts containing 2 percent and 5 percent of chlordane were dusted into a petri dish, mites were placed on the dusted surface, and the dish was covered to prevent their escape. There were no dead mites in the chlordane tests at the end of 48 hours.--Hixson and Muma (219).

Otobius megnini (Duges), the ear tick

A mixture of 5 parts of chlordane and 95 parts of pine oil introduced into the ears of cattle remained effective for 22 days and was considered at least as effective as a mixture containing 5 percent of BHC in repelling larvae of this tick.--U. S. Bur. Animal Ind. (465).

Psoroptidae

Psoroptes equi var. cuniculi (Delafond), the ear mite

These mites on a rabbit were not killed when the rabbit was fed chlordane.--Knipling et al. (266).

Demodicidae

Demodex canis Leydig, the dog follicle mite

Sarcoptidae

Sarcoptes scabiei canis (Gerl.), mange or sarcoptic mite of dogs

Five dogs heavily infested with sarcoptic mange, of which 3 had lesions of demodectic mange, were treated with an emulsion of 0.25 percent chlordane. All treatments were applied by dipping the animals and holding them in the liquid for from thirty to sixty seconds with at least two complet submergences. The dip was warmed to a temperature of 100 to 110° F. Exceptionally large or heavy demodectic lesions were scrubbed with a firm-bristled brush while the animal was in the liquid. The dogs treated with chlordane were allowed to run with untreated animals. One of the chlordane-treated dogs that was heavily infested with sarcoptic and demodectic mange also had several small demodectic lesions three weeks following treatment. As isolation of the test animals was not complete, no further checks on the test were made. None of the animals showed any ill effects from the treatments.--Muma and Spencer (336).

Chlordane was effective in treating common and red mange in dogs. The dogs were dipped in a 50-gallon barrel half filled with a 0.25 percent chlordane solution, and held in the dip for 30 to 60 seconds.--Spencer (433, 435).

Sarcoptes scabiei suis (Gerl.)

One application of a 0.25-percent chlordane solution thoroughly applied completely cleaned up sarcoptic swine mange on 800 infested hogs in Nebraska. The 0.25-percent chlordane solution was made by adding 500 ml. of 74-percent emulsifiable concentrate to 50 gallons of water. This was applied with a power sprayer using from 1 to 2 quarts per head with from 50 to 250 pounds of pressure.--Spencer (433-435).

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Tetranychidae

Paratetranychus citri (McG.), the citrus red mite

In laboratory tests the 24-hour median lethal concentration of chlordane to the mite was 1.0 percent.--Metcalf (324).

Tetranychus bimaculatus Harvey, the two-spotted spider mite

Dusts containing 2 or 3 percent of chlordane were less effective than dusts containing 5 percent of azobenzene or 0.5 percent of parathion in controlling the two-spotted mite on lima beans, also chlordane sprays of 1 or 2 pounds of 20-percent wettable powder per 100 gallons of water were less effective than sprays of toxaphene, benzene hexachloride, azobenzene, and hexaethyl tetraphosphate.--Huckett (229).

A spray of chlordane 50-percent wettable powder (0.125 percent chlordane) was applied to soybean plants which were then infested with mites. After 19 days the number of live mites on the bean foliage was about the same as in the test where 0.125 percent DDT was applied. The parathion sprayed soybeans showed the lowest populations of mites and eggs at the end of the tests.--Wingo and Thomas (502).

Tetranychus pacificus McG., the Pacific mite

Chlordane at 0.5 pound of 50-percent emulsion for 100 gallons of water controlled Pacific mites well until the end of June, but after that, although the trees were sprayed seven times altogether, control was poor. These tests were made at Yakima, Washington in 1947.--Newcomer and Dean (346).

Tetranychus spp.

Red spider infestations on cotton developed in some cases where a dust containing 3 percent of chlordane and 3 percent of DDT was used.

Against the red spider 10-percent chlordane was more effective than sulfur.--Bishopp (32).

The red spider on cotton is not controlled by chlordane.--Harned (205).

In the state of Washington in 1947 chlordane proved relatively ineffective against mites, but controlled the woolly aphid to some extent. It does not seem to have a place in the orchard spray program.--Newcomer (345).

Trombiculidae

Trombicula (Eutrombicula) splendens Ewing

T. (Eutrombicula) alfreddugesi (Oud.), the chigger

Applied as an emulsion, chlordane at 8, 4, and 2 pounds per acre gave control equal to that of hydroxypentamethylflavan at 4 pounds per acre throughout the 17-day period of observation.—Smith and Gouck (422).

Applied as a dust or spray at the rate of 2 or 4 pounds per acre, chlordane compared favorably with other miticides, such as benzene hexachloride and hydroxypentamethylflavan.--Knipling (264); U. S. Bur. Ent. and Plant Quar. (468).

Trombidiidae

Eutrombidium trigonum (Herm.), the red grasshopper mite

Very few grasshopper mites were killed by chlordane, 3/4 or 1 pound per acre, applied for the control of grashopper.— Severin (413).

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